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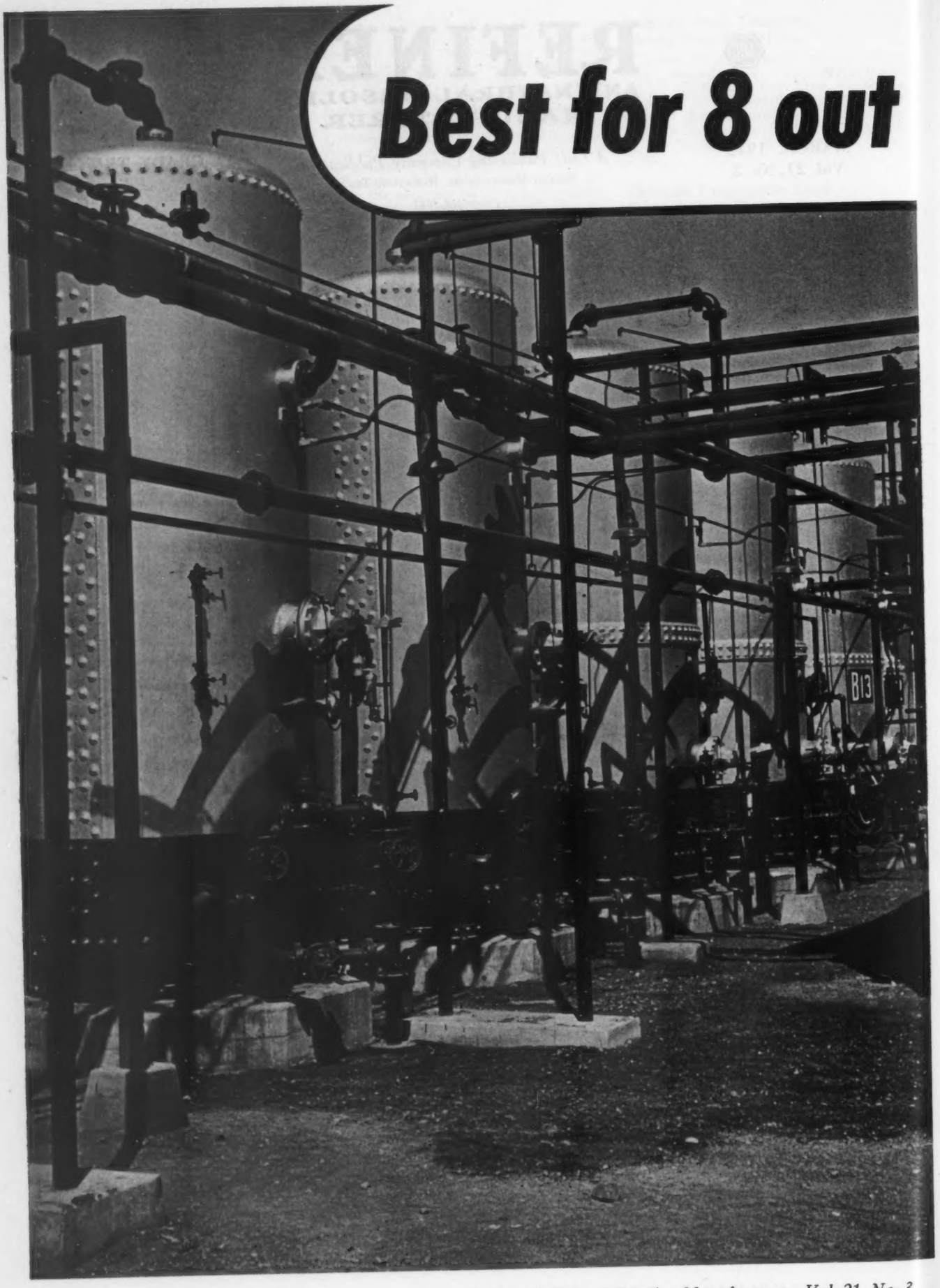
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VOLUME 21, No. 3 MARCH, 1942

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A GULF PUBLISHING COMPANY PUBLICATION

THE LOOK BOX

War and Equities

RAY L. DUDLEY, Publisher

HERE is something every American man and woman must realize:

Equities which stand in the way of winning this war will and should have scant consideration at the hands of the public.

All of us believe in the general principle of this statement. We know that when a man has given his life at the battlefront he has given more than can be contributed by those who stay at home.

Just as we would condemn the *wanton* loss of life in battle through incompetence, or treason to the cause, so we condemn the *unnecessary* destruction of equities, of rights to and in property.

But just as we know there must be loss of life in combat, we know that there will have to be losses on the industrial front.

Unfortunately, it is difficult for us to realize that sacrifices, or loss of equities, should not just affect the other fellow.

The man or company owning a plant often does not believe that it should be jeopardized because of a WPB or OPC rule. And if safeguards can be raised against the loss of properties, they should be raised and those in government should be concerned and aggressive in the erection of the safeguards. This is no more unreasonable than that the lives of the soldiers be safeguarded with whatever provisions can be made without decreasing their fighting power. But if such safeguards cannot be raised, and the loss of the equity becomes necessary to the winning of the war, then the equity will have to be foregone.

The industry which takes an opposite stand will pay dearly for its shortsightedness. The company, or individual, attempting to save its own hide at the expense of others will be no less condemned. The politician, the labor-union leaders, who think that this is a struggle in which he, or they, are immune from sacrifice, will be tried and condemned before that greatest of all our tribunals—American Public Opinion, and it is not likely that a suspended sentence will follow.

This war in which we are engaged is no civil war in which both sides are composed of men with similar ideas of government and conduct. It is no Spanish-American war, no World War I in which the issue was never in doubt from the time we entered it. It is a war to the death. It will determine the fate of a world, and our enemies are prepared as we never dreamed of preparing before Pearl Harbor.

The toll in blood, lives and properties, will be on such a scale as we have never before contemplated. It calls for national leadership which is closely identified with military and naval leadership as we have already seen. That we shall have mistakes in the part of that leadership seems inevitable, but that does not give any American citizen or corporation the right to limit its part in the national defense or offense to criticism alone.

This war is now a war of production. Later this

production will permit of a war of relentless action.

In the war of production we have suffered from an impractical attitude on the part of our national administration, and the stern necessities facing us require greater sacrifices than might have otherwise been necessary.

But we must not cry over spilled milk. Part of our difficulties are being smoothed out. In large part, we believe, they will all be smoothed out.

Recently we listened to Donald Nelson, our leader in the war of production, speak to the editors of 150 business papers covering every conceivable industry in this country. We wish that every man in the oil industry could have heard him.

There was no trick of oratory, no attempt to develop the emotions. There was straightforward earnestness and common sense in his thoughts and words which struck to the hearts of his listeners. If he is not the man for whom we have been looking, then all signs fail.

His thinking as expressed by what he said was sound Americanism. We shall be glad to take our chances with his leadership.

Many things he said were significant, and we want to leave some of them with you:

> "American industry is on trial, the man in the street will hold you and us to account . . . This country faces the most gigantic job any country ever faced . . . It is necessary to keep American industry sound . . . We must get out today the things we would have gotten out tomorrow . . . We must do things we never thought we would have to do . . . *Those of you who fear a change in our form of government will see it more likely happen if you leave this job to the government to do it for you.*"

In the oil business we have a peculiar job to do. It is divided into two parts. The first part is to produce and refine what oil will be needed—in itself a big job. The second is to do it with an unbelievably small amount of materials.

Oil men must know that not only will there be a great dearth of the raw materials from which their equipment is made, but that every factory capable of doing even the smallest part of a defense job will be hard at work on armaments before this year is out. Plants which have been thought too small to be considered, or which have met no encouragement in their efforts to get defense orders will be put to work.

There will be needless sacrifices required—foolish, senseless sacrifices in our industry, unless the best thought of the industry, *unselfishly* applied, is put to work. There never was a more necessary time for sober, constructive thinking—and *unselfish sacrifice,* in our industry than right now.

Little Light On Blackouts

EVIDENTLY the refining industry is without a central source of information on plant blackout requirements. Managers of plants are aware of the need but letters indicate that confusion results when an effort is made to learn what requirements to meet.

A plant whose products are going into military use has the advantage of the military service branch to which merchandise is moving. Thus, a plant which provides aviation gasoline, can call upon the Army Air Corps. This is true with the Navy and the Army.

While this takes care of most of the large refining plants, it leaves numerous smaller ones without specific information. There is an impression that the Office of Civilian Defense should serve in these instances. Also the Office of the Petroleum Coordinator is considered a proper source of information. There is a committee on plant protection and sabotage within the industry.

All of these have made studies. Thus far the information has not been put into a set of definite instructions which will lead to essential requirements. This is needed and needed immediately.

In Europe equipment and methods have been worked to the perfection of bringing a refining plant to the blackout stage within one and one-half minutes.

Until standards are set up and requirements set forth by some central authority, domestic refining plants and natural gasoline plants will not accomplish what is being done elsewhere.

Time to Examine Obsolete Units

SO FAR as refining is concerned, the admonition to get scrap steel back to the mills involves more than systematic collection of junk. This industry has several thousand tons of steel about which decisions must be made. All manner of estimates are made as to the obsolete refining capacity.

The units not in use but held against possible rehabilitation are doubtless the chief source of scrap steel. Whether to dismantle and regret or to leave standing and regret are the questions. Some authorities say that as much as 800,000 barrels of daily capacity is of doubtful further value in refining.

It is the obligation of executives and process experts to examine the full total of this equipment in the light of future use on one hand and the immediate need for steel on the other. The more that can be moved into scrap channels the better. Along with dismantling there should be examination for rehabilitation. A refining unit may pass beyond its economic usefulness and still hold usable parts.

Natural Gas as a Raw Material in the Production of Synthetic Ammonia

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AN ANALYSIS of world conditions relative to nitrogen requirements suggests that future demands dictate doubling the present capacity in the United States when investigated in terms of synthetic ammonia. The chemical industries have noted this condition in addition to being aware that synthetic ammonia fulfills both peacetime and wartime needs more so than nitrates as found in Chile. Synthetic ammonia production in the Axis-dominated countries is estimated[1] at 2,775,000 tons leaving but 1,135,000 tons of capacity for the rest of the world. The 1940 peace time output of the United States is estimated[2] at 260,000 tons, with total defense needs estimated at 550,000 tons.

This condition focuses interest on the raw materials used in these synthetic processes.

At the present time, of the gases used in this synthesis, the most expensive and difficult to obtain is hydrogen. Hydrogen may be separated from coke-oven gas, obtained as a byproduct in certain cracking processes, in the alkali-chlorine industry and certain fermentation processes or quite pure as electrolyte hydrogen should cheap current be available. Three-fourths of the synthetic ammonia production is now made by the water-gas reaction using coke or anthracite coal as raw material, this process yielding both the hydrogen and nitrogen required.

Although there are but few plants operating in the United States and Canada at this time using natural gas as a source of hydrogen for this process, the future should see an increasing number of such plants in operation. This paper will briefly review the water-gas process, the steam conversion process, and products from synthetic ammonia relating to explosives.

At the close of the Nineteenth Century Sir William Crooks informed the world that unless some other source of nitrogen was found other than the Chilean nitrate beds, the world at some future date would starve to death. An analysis of nitrogen needs during peacetime indicates that 70 percent must be applied to the soil as fertilizers while 30 percent finds use in industry. Today the amount of fixed nitrogen used, far exceeds natures production and this ratio increases rapidly under wartime conditions.

This condition prompted chemists to work on this

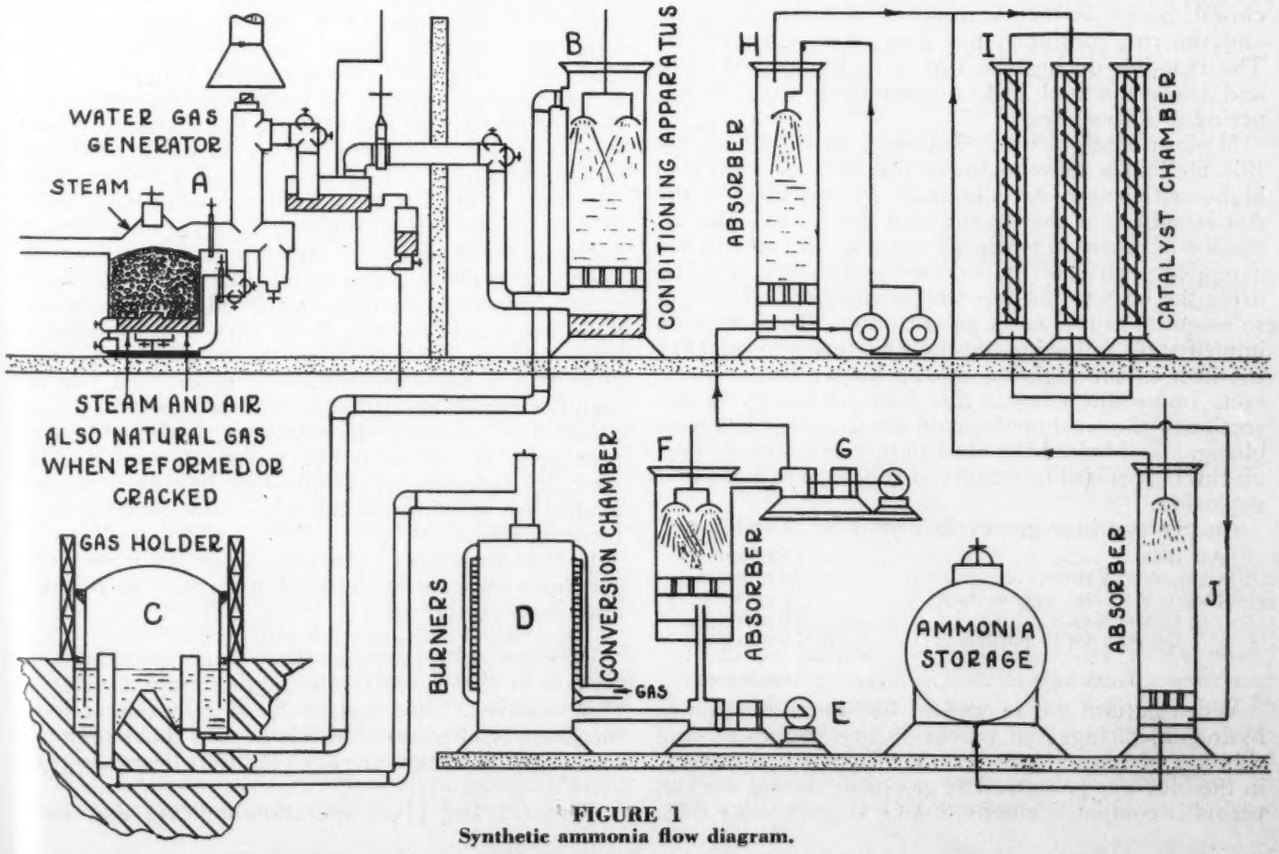


FIGURE 1
Synthetic ammonia flow diagram.

problem from 1900 on and although there were many who contributed, without a doubt it was Haber, a German chemist, who made possible the synthetic ammonia process. It was about 1913 that one of the first plants of this type was erected and operated in Oppau, Germany. This accomplishment may in part have prompted the march of the German army in the first World War after Haber's accomplishments had insured a supply of fixed nitrogen for wartime needs.

In the modern synthetic-ammonia process by far the greater amount of hydrogen is made by the water-gas reaction. Figure 1, is a flow diagram of the process on the order of the original Haber plant. Today finds changes in this process, chiefly in pressures, temperatures and catalysts. Since most of this information is confidential, the following is a broad discussion of the original plant operation.

In the water-gas process, in general, anthracite or coke is used as raw materials and it has been reported[3] that natural gas may also be used as a raw material being injected on the run, see A, Figure 1. Both nitrogen and hydrogen can be obtained in this process, the nitrogen from the blast products and hydrogen from the run, the required amount of nitrogen being added before the mixed gases are sent to the reaction chamber. In addition hydrogen may be made separately by the water-gas process and all the nitrogen requirements supplied by the Linde process.

Briefly the water-gas process consists of arranging a blue water-gas set for the manufacture of blue water gas alone. When the apparatus is brought up to a heat a definite cycle is placed in operation. In general this cycle is from 4 to 6 minutes in length and consists of blasting uprun, down run, and up purge periods. First, air is introduced beneath the grate and brings the apparatus up to heat. Approximately 25 percent of cycle is for blasting after 1.0 to 1. minutes the blast is shut off and the stack valve closed. Steam is then introduced beneath the grate and the run continued for about 3 to 4.5 minutes. The reaction during the run is highly endothermic and cools the fuel bed, necessitating the blasting period to restore heat.

Modern blue-gas operation employs split runs. By this method a more uniform fire may be kept and higher efficiencies are obtained. In this method the run is split into the up run and down run. The inclusion of steam beneath the grate on the up run has a tendency to cool the bottom of the fire bed and drive the heat to the top, decreasing time of contact so essential in the water-gas reaction. The down run, immediately following the up run tends to equalize the heat in the fuel bed, giving longer time of contact. Immediately after this part of the cycle the section of the machine beneath the grate is filled with blue-gas and before the blast is resumed a very short up run is required to steam out this section and avoid explosion.

An average blue-gas cycle would be as follows:

Air Blast	1.5 minutes
Changing Valves	0.5 minutes
Steam Run and Steam Purge	
Down Run	2.0 minutes
Up Run (with purge)	2.0 minutes
Total	6.0 minutes

When natural gas is cracked for the production of hydrogen, changes in operation are suggested and this use of natural gas will be discussed separately in the blue-gas process. The gas made during the run period is composed chiefly of CO, H_2 and some CO_2.

(1) $C + H_2O \rightarrow CO + H_2 - 56{,}720$ Btu.
(2) $C + 2H_2O \rightarrow CO_2 + 2H_2 - 38{,}480$ Btu.
(3) $CO + H_2O \rightarrow CO_2 + H_2 + 18{,}240$ Btu.
(4) $C + CO_2 \rightarrow 2CO - 74{,}960$ Btu.

During the blow the gas is composed chiefly of CO_2 and N_2.

(5) $C + O_2 \rightarrow CO_2 + 169{,}680$ Btu.
(6) $C + CO_2 \rightarrow 2CO - 74{,}960$ Btu.
(7) $2C + O_2 \rightarrow 2CO + 94{,}720$ Btu.
(8) $2CO + O_2 \rightarrow 2CO_2 + 244{,}640$ Btu.

Nitrogen from air accompanying oxygen, not shown in reactions (5) to (8).

In this process these gases are first cooled and then cleaned, at B, of tar and other undesirable matter and then stored in the gas holder C where mixing could give the desired volumetric ratio of nitrogen to hydrogen, however, this desired ratio of hydrogen to nitrogen is generally obtained at a point in the process after the conversion of carbon monoxide into carbon dioxide. The gas is then cleaned of its sulphur content by dry box or liquid purification. In the chamber D, at this point, one of the chief difficulties of this process is encountered, the removal of the carbon monoxide. This is obtained by passing the gas over ferrous oxide catalyst and although that the oxidation reaction of CO to CO_2, by steam, with the subsequent formation of hydrogen is exdothermic heat, must be added at this point

$CO + H_2O \rightarrow CO_2 + H_2$ (Exdotherimc at 500° C.).

This method reduces the carbon monoxide concentration to a small percentage (about 2 percent). The gas is compressed, E, to about 450 pounds per square inch and then conducted to tower F where on being scrubbed with water all but about 0.1 percent of carbon dioxide is removed. It is reported[4] that 70 percent of the energy used to compress the gas is recovered by releasing the pressure on the water solution of carbon dioxide.

The gas is then compressed, G, to pressures used in the synthesis and the remaining carbon monoxide removed in the tower at H. The absorbent employed here may be ammoniacal cuprous solution or the gases may be passed over a methanol catalyst.

The gaseous mixture of hydrogen and nitrogen is then conducted to the catalyst chambers, I. These chambers are reported[4] to be on the order of 40 feet in length with 3.5 feet outside and 1.5 feet inside diameters. The chambers are designed in some cases of two shells with insulating layers and a section between shells in which nitrogen is confined at the operating pressure. The metal used in this chamber is of extreme importance as at high pressure the hydrogen would react with the carbon in the steel to form methane. Alloys have been used consisting chiefly of a high percentage of nickel and the remainder chronium although the reaction of the synthesis is exdothermic the entering gases must be first preheated to the reaction temperature and with specially designed apparatus this has been accomplished by winding the outside of the chamber with resistance wire.

In the formation of synthetic ammonia from nitrogen and hydrogen the thermodynamics of the reaction must be investigated.

$N_2 + 3H_2 \rightleftharpoons 2NH_3$ (Exdothermic)

Pressure will increase the amount of ammonia formed in that there is a reduction from 4 volumes to 2 volumes. The reaction speed is accelerated by increased temperature but this in turn shifts the reaction to the left (exdothermic reaction) decreasing the yield of ammonia.

Research and plant operation indicate that pres-

TABLE 1
Typical Analysis of Cracked Gas and Natural Gas in Carbon Black Reforming Process [After Duesler[5]].

	Natural Gas	Reformed Gas	Reformed Gas	Reformed Gas
Percent by volume:				
Carbon dioxide	..	0.5	0.5	0.5
Illuminants	..	0.5	1.0	0.75
Oxygen	..	0.5	0.5	0.50
Carbon monoxide	..	3.0	3.5	3.25
Hydrogen	..	93.0	88.0	90.00
Methane	80	1.0	5.0	3.50
Ethane	10	..	..	..
Propane	4	..	..	..
Butanes	2	..	..	..
Nitrogen	..	1.5	1.5	1.50

sures varying from 1500 to 15,000 pounds per square inch are required, the highest yield about 65 percent with 15,000 pounds per square inch. Average yields of 5 to 15 percent and 3,000 pounds per square inch pressure are common. The temperatures used in the synthesis vary from about 500° C. to 700° C. The catalyst generally used is spongy iron containing varying amounts of promoters such as aluminum and potassium.

The gases on leaving the synthesis chamber, ammonia, and that part of unchanged nitrogen and hydrogen, are conducted to the tower, J, where part of the ammonia is scrubbed out with water. Part of the ammonia remains with the unreacted nitrogen and hydrogen and recirculates through the synthesis chamber to aid in maintaining correct chamber temperature. Plants with 50 percent or higher conversion do not recycle the unreacted hydrogen and nitrogen. Those plants with less than 50 percent recovery recycling these products must periodically remove the recycled gas in that the concentration of inert gas increases.

Natural Gas As a Source of Hydrogen and Carbon Black

As previously stated, natural gas may be used as a source of hydrogen and this operation can be attained in a blue-water-gas machine using coke for a fuel bed. Large-scale experiments have been conducted and the various stages in this work have been reported by Odell[3] and Duesler[5]. These experiments were conducted in order to ascertain if it would be possible to use the gas formed by this process for mixing, or as a source of hydrogen for synthetic ammonia, synthesis of methanol or other chemical products.

This process consists chiefly in blasting a bed of coke in a water-gas generator, Figure 1, A, to a temperature in excess of 1,200° C. and then passing natural gas through the incandescent coke. About 92 percent of the hydrocarbons are cracked to hydrogen and carbon when space velocities up to 12 cubic feet of natural gas per square foot of grate area per minute are employed. In this process methane is the heaviest hydrocarbon not cracked and Table 1, gives the analysis of the raw material used together with the cracked gas.

This process in addition to producing hydrogen yields carbon black which may be recovered. It is reported[5] that from four to eight pounds of carbon black per 1,000 cubic foot of natural gas processed may be recovered. The quality of this carbon black may be varied and its use for rubber compounding is suggested. The characteristics of one type of carbon formed was reported[5] as shown in Table 2.

Should the recovered carbon black be suitable for rubber compounding, it should be worth 10 times as much per pound as the coke used. Under these conditions 5 to 8 pounds of carbon black recovered per thousand feet of natural gas cracked compares favorably with the 30 pounds of coke used as generator fuel.

The coke used in this process was found[3] to give satisfactory results when it ranged in size from 4 to 6 inches. Clogging of the fuel bed was eliminated by using steam alone, on the run, instead of natural gas every third run. This gave a gas of about 25 percent blue-gas and 75 percent reformed gas and in that these gases were not made simultaneously they could be stored separately or mixed and treated after the same fashion as previously discussed in the production of synthetic ammonia.

An average cycle would be as follows: after Duesler[5].

Air Blast		3.5 minutes
Changing Valves		0.5 minutes
Gas Run and Steam Purge		
Down-run	5.5	minutes
Up-run	4.5	10.0 minutes
		14.0 minutes

In addition this process in turn yields blasts products which may be used as a source of nitrogen in the ammonia synthesis.

Natural Gas a Source of Blue-Gas

A satisfactory method has been found[6] where natural gas can be reformed in a standard water-gas set. (With slight modification). The thermal efficiency of the process is high and the carbon entrained in the gas is reduced to almost zero.

In the operation a cycle of alternate blows and runs are used, the natural gas being introduced with the steam during the run. This process allows the carbon of the gas to combine with the oxygen of the steam to form carbon monoxide and set hydrogen free. Methane, ethane, propane and butane would react as follows:

(1) $CH_4 + H_2O \rightarrow CO + 3H_2$ (Endothermic)
(2) $C_2H_6 + 2H_2O \rightarrow 2CO + 5H_2$ (Endothermic)
(3) $C_3H_8 + 3H_2O \rightarrow 3CO + 7H_2$ (Endothermic)
(4) $C_4H_{10} + 4H_2O \rightarrow 4CO + 9H_2$ (Endothermic)

The operating results in reforming natural gas at Toledo, Ohio, as reported by Burdick[7] are as follows:

Operating Cycle

Blow	1.5	minutes
Up-Run with Steam	1.5	minutes
Back Run with Steam and Natural Gas	2.25	minutes
Purge with Steam	0.5	minutes
Valve Changes	0.25	minutes
Total	6.0	minutes

Reformed Gas Analysis

Carbon Dioxide	1.6
Oxygen	0.5
Hydrocarbons	10.6
Carbon Monoxide	23.8
Hydrogen	56.1
Nitrogen	7.4
Heating Value	372.0
Specific Gravity	0.431

This process was developed primarily to produce a reformed gas using natural gas as a raw material to provide a gas mixture of predetermined thermal and flame propagation characteristics to be mixed with coke-oven gas for distribution to domestic and industrial customers in and about Toledo, Ohio. In the production of synthetic ammonia this type of reformed gas would have to be processed to oxidize the carbon monoxide and remaining hydrocarbons as previously outlined in the modified Haber process.

TABLE 2
Characteristics of One Type of Carbon Made[5].

Time of Cure at 287° F.	Tensile at Break Lbs. Per Sq. In.	Percent Elongation at Break	Tensile at 400 Percent Elongation	Hardness Shore Durometer
30′	3825	667	1055	50
40′	3925	625	1330	52
60′	3300	555	1650	54
80′	3215	530	1810	55

Although this process could be used as a source of hydrogen and nitrogen the economics of the operation favor the process in which natural gas is cracked and the carbon black removed.

In addition to the cracking and reforming processes in the water-gas apparatus method consists of utilizing the combustion of gas to heat cracking chambers of refractory materials to a temperature sufficient to crack the gaseous hydrocarbons.

In the past, the locations in which hydrogen has been produced for the manufacture of ammonia, the value of natural gas from a Btu. standpoint was higher than that of coke. Therefore under these conditions it is feasible to use coke to furnish heat for the process. In addition the transfer of heat to a mass of gas by direct contact with an incandescent material brought to incandescents by its own combustion should be more desirable than heat radiated by refactory materials previously made incandescent by heat from products of combustion. However, where large volumes of natural gas are available at reasonable costs this economic condition favors the process in which natural gas is used as a fuel and raw material in the production of hydrogen.

When economic conditions are such that natural gas may be used as a fuel and raw material in the production of hydrogen there are a number of processes by which this gas may be cracked or reformed. These processes make use of different forms of standard gas-making equipment such as is used in the Dayton oil-gas process or the Haber process[8] or the various Pacific oil coast oil gas generators[9] as employed in gas production in Pennsylvania and on the Pacific Coast respectively. Present day methods employed on a large scale to produce hydrogen from natural gas are based on a steam conversion process for which the Standard Oil Development Company holds the patents.

Hydrogen From Natural Gas by the Steam Conversion Process

The steam-conversion process of producing hydrogen from natural gas has been employed successfully in the hydrogenation of petroleum. This process has been practiced commercially in the United States at Baton Rouge, Louisiana; Bayway, New Jersey; Port Arthur, Texas[10], and at other locations. In addition, the steam conversion process is being employed to produce hydrogen in synthetic amonia production in Canada and it is very probable that such plants are being planned at unknown locations here in the United States.

A general outline of this process may be obtained by referring to Figure 2. The initial re-forming is carried out in the furnace, A. This radiant-type downflow furnace, gas-fired, is maintained at a temperature of 1600° F. The gas to be processed plus

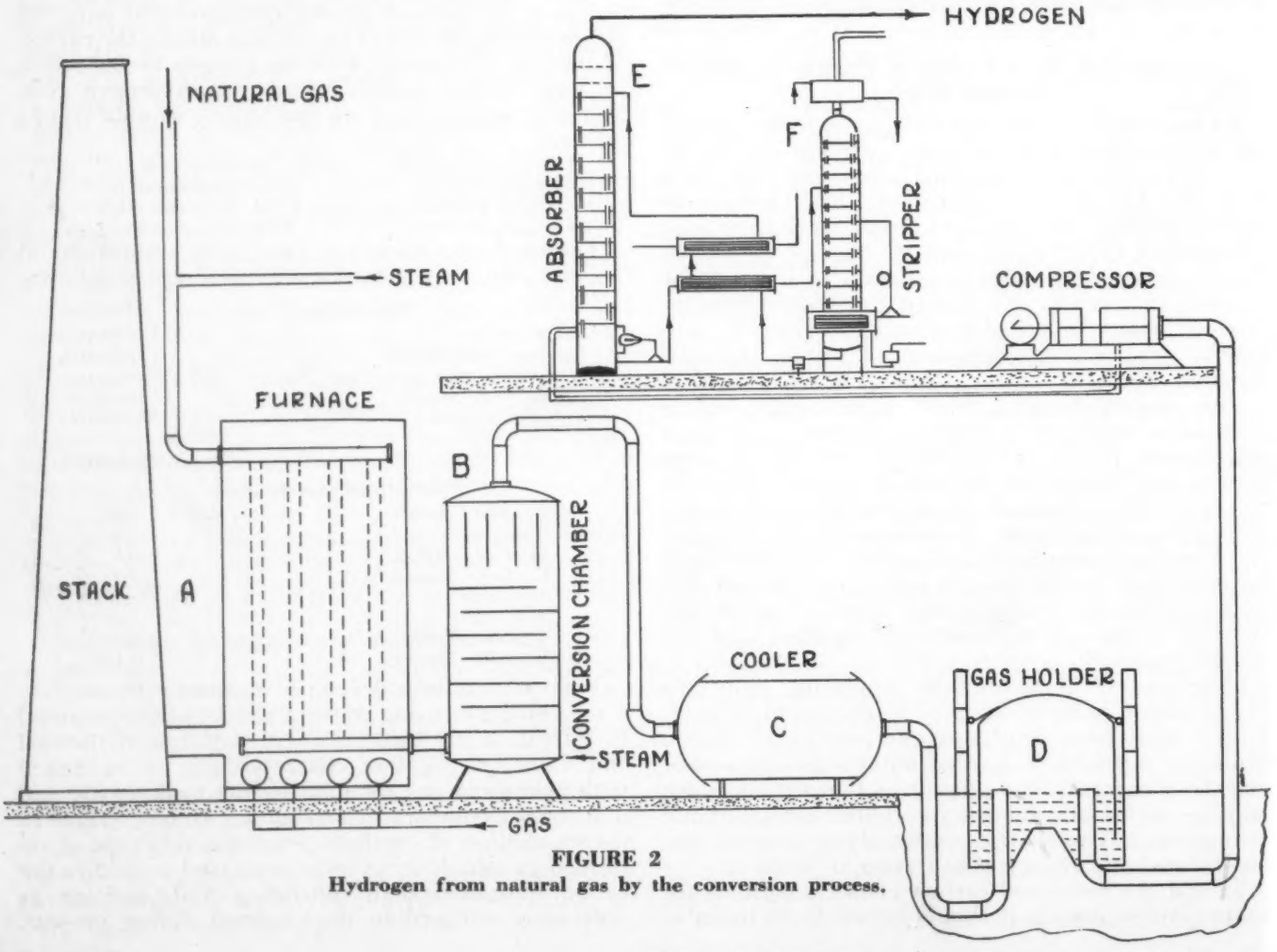
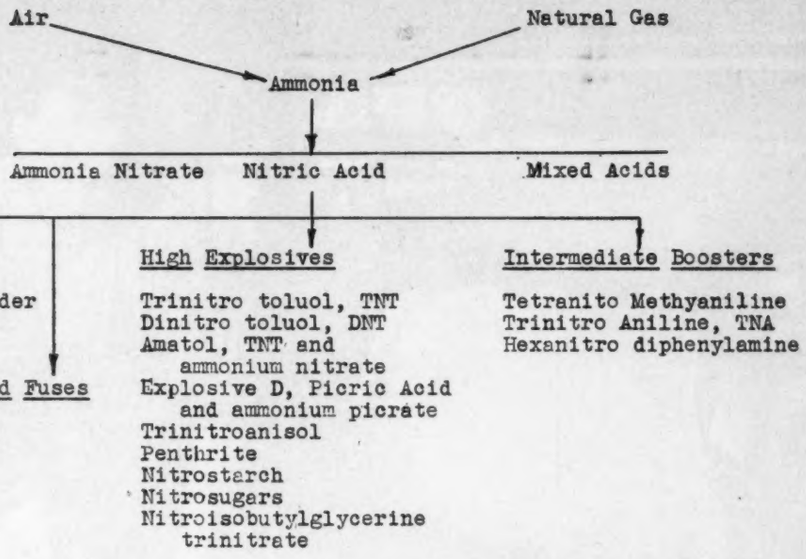


FIGURE 2
Hydrogen from natural gas by the conversion process.

Table III. NITRO COMPOUNDS



steam is passed through tubes packed with catalysts. The reaction taking place in this stage is as follows:

$CH_4 + H_2O \rightarrow CO + 3H_2$ (Endothermic).

In this stage approximately atmospheric pressure is maintained in the system, the gases are then conducted to the convertor, B, where additional steam is added and at a temperature of 850° F. with another type catalyst, the production of hydrogen is completed:

$CO + H_2O \rightarrow CO_2 + H_2$ (Exdothermic at 500° C.)

The gas is then cooled at C, and conducted to the gas holder D, before being compressed. The analysis of this gas, at this point in the system, is reported[11] to be roughly 78 percent hydrogen, 20 percent carbon dioxide, and 2 percent unconverted hydrocarbons and other gases. It is extremely important that the natural gas used in this process be free of any sulphur compounds, such compounds resulting in catalyst poisoning.

From the holder the gas is compressed to 250 pounds per square inch and then conducted to the scrubber E, where the carbon dioxide is absorbed in a solution of triethanolamine.

Triethanolamine, $N(CH_2CH_2OH)_3$

The absorbed carbon dioxide is stripped from the circulating medium in the stripper F, at atmospheric pressure with steam and the liquid recycled to the absorption tower. In ammonia production, as previously explained, the carbon dioxide under pressure is absorbed in a water solution, this method could be substituted for the triethanolamine process.

The scrubbed gas on leaving the absorption apparatus is approximately 97 percent hydrogen. This mixture is compressed and then processed for ammonia production after a general fashion as previously outlined. The steam conversion process supplies only the hydrogen used in ammonia synthesis, therefore, the nitrogen required is obtained from the atmosphere by liquidification and fractional distillation procedures.

The significance of ammonia in war time is very evident when Table 3 is inspected. Woodward[1] has discussed this subject in detail and lists various nitrogen compounds used in modern warfare which are derived from ammonia. The oxidation of ammonia yields nitric acid and this acid with ammonia yields ammonia nitrate. With these base materials explosives are prepared which are being used in great quantities for charging airplane bombs, shells and other projectiles.

Synthetic ammonia is not only of extreme importance in wartime, but future peacetime needs should demand a steady increase in its production. In addition to its use as a fertilizer base, rubber accelerator, and as a dye intermediate, the development of nitroparaffins and the long list of their derivatives appears to be assured. The development of these peacetime processes employing the basic raw materials so essential in wartime allows for the desirable change over when peace returns to America.

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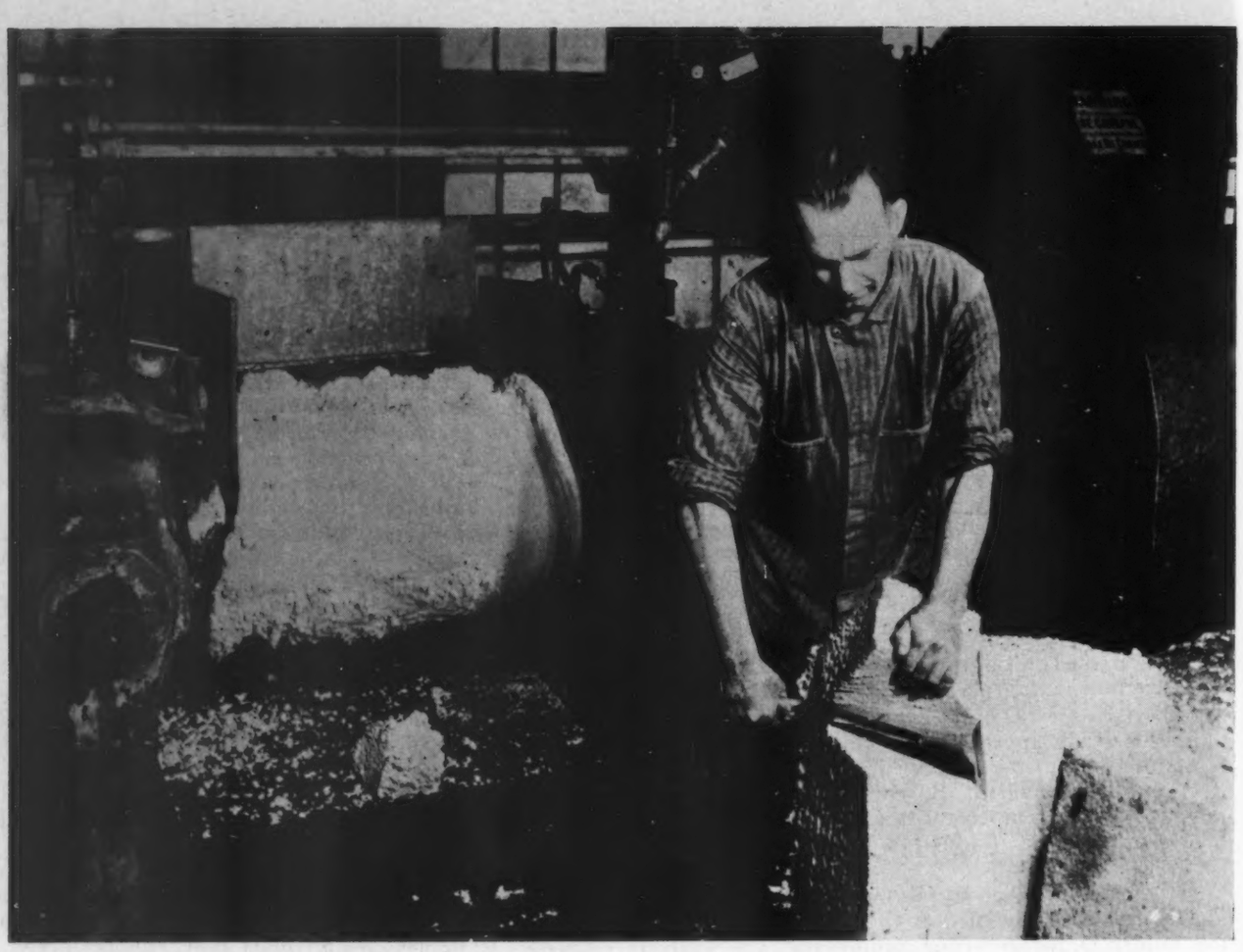

Synthetic Rubber . . .

Problem and an Opportunity

J. V. HIGHTOWER

IN THE synthetic rubber program the refining industry faces both a problem and an opportunity. Because of its resources in raw materials, the oil industry is shouldering chief responsibility for assurance that the war program will not be crippled by stoppage of natural rubber supplies from the Far East. The principal basic material to make synthetic rubber—petroleum—is abundantly available. The problem involved in the conversion of this material is complex. It involves such questions as what types of rubber to make, what petroleum products to use in making the ingredients of the rubbers, what types of equipment are necessary, and what the probable demand for synthetic rubber will be. The opportunity facing the industry is the development of a new market which may cut into if not eliminate the need for natural rubber. Such development necessitates installation of new equipment, both to recover raw materials at present potentially available and to increase the supply of these materials.

With respect to types of synthetic rubbers required, current information indicates that Buna rubbers will be in greatest immediate demand. E. R. Weidlein, head of the chemicals branch of the late OPM, said in January the current program is to concentrate on manufacture of Buna rubbers, raw materials of which come largely from petroleum. This program was announced when Jesse H. Jones, chairman of the Reconstruction Finance Corporation, revealed that $400,000,000 would be spent for the enlargement of our synthetic rubber capacity to 400,000 tons per year by the middle of 1943. Dr. Weidlein

pointed out that by concentrating on Buna production, the use of large quantities of chlorine, used in some other types of synthetics, could be avoided. Furthermore, the supply of hydrocarbons used largely in the Buna rubbers is potentially great. A third consideration is that at least one variety of Buna rubbers has satisfactory qualities for tire and tube production, which has been consuming 70 percent of our rubber supplies.

Types of Rubbers

Because a detailed survey of characteristics of the various synthetic rubbers would be too long for treatment here, only a few features of the more widely known rubbers can be outlined. The Buna rubbers, notably Buna S and Buna N, consist largely of butadiene polymerized with (1) styrene in the case of Buna S and (2) acrylonitrile in the case of Buna N. These rubbers are vulcanizable. Buna S is reported well suited to tire manufacture,[1] more so than Buna N, though extensive road tests have been made with both types. High resistance to destructive action by gasoline, oils and many organic solvents qualify Buna N for numerous specialty services.[1]

Butyl rubber, like the Bunas, is basically composed of hydrocarbon gases obtainable in the oil industry. This is a product resulting from the polymerization of butylenes or other olefin gases with small amounts of butadiene.[2] The product has the advantage of being made from olefins which are produced in greater volume in refineries than butadiene, but was recently declared as not yet developed as well as Buna as a material for tires.[3] This rubber is quite stable, chemically speaking, resistant to the passage of gases, is vulcanizable and adapted to specialty uses, though is not resistant to the action of naphthas.[4]

Another specialty synthetic made from hydrocarbon gases is Vistanex, a product of polymerization of isobutylene. The material is suited for use in conjunction with natural rubber in tires and tubes and for manufacture of gas masks, leak-proof gas tanks and balloon coverings.[5]

Other synthetics with good chemical stability and specialty uses are Chemiguim and Ameripol, both of which involve the use of butadiene, and Thiokol, a rubber made from ethylene, another hydrocarbon gas produced in cracking operation.[6]

Neoprene, a synthetic which last year led the others in production, utilizes acetylene gas as a raw material. The gas is polymerized to monovinylacetylene, which is treated with hydrochloric acid to produce chloroprene. In turn, chloroprene is polymerized to form the synthetic rubber. It has been widely tested in tires and the manufacture of specialty products. Neoprene is rated high in resistance to abrasion and to chemical action.

Butadiene Comes First

If in accordance with Dr. Weidlein's statement last January the wartime program is to center on production of the Buna-type rubbers, it is apparent that butadiene will be the chief raw material to be produced by the oil industry, since butadiene constitutes 70 to 80 percent of the rubber composition. Styrene, used with butadiene to make Buna S, is produced outside the oil industry, but could be made from petroleum if required. There is no question that petroleum resources are more than sufficient to produce the needed quantity of butadiene. This statement was recently made by a synthetic rubber authority in one of the major oil companies, who pointed out that the bottleneck in production would be availability of manufacturing equipment. Lightbown and Britton[7] declared last April that "It is interesting to note that on a weight basis, our annual import of crude rubber is only about one third of 1 percent of the crude oil produced. Clearly, then, there need be no concern over the question of raw materials for supplying any reasonable demand for rubber via the synthetic route."

What particular petroleum products to use in producing butadiene (and other gases to the extent they may be used) is a problem that the oil industry and the Office of Petroleum Coordinator are studying. During the 1942 annual convention of AIME, W. W. Gary, director of refining in OPC, declared that either natural gas or petroleum oils may be used, the choice depending on local conditions. It is obvious that the problem has no simple answer. Butadiene and other unsaturated hydrocarbons used in making rubber do not occur naturally in natural gas and oils except in rare and negligible instances, and must be manufactured from such materials.

Sources of Raw Materials

Natural gas, specifically the butane fraction in the gas, or the natural gasoline derived from such gas may be employed. OPC has been conducting a survey of available hydrocarbons in the country, and it may well be that the final development of the synthetic-rubber program will involve the natural gas and gasoline industry as an important contributing source of supply. Butadiene can be produced from the butane fraction in both natural gas and natural gasoline by extracting this fraction and then dehydrogenating the butanes at high temperature and low pressure either thermally or catalytically. Since the processing of small quantities of butanes would not be economical, as Gary pointed out a possible development in the use of natural gas as a synthetic rubber source is the shipment of liquefied butanes from scattered extraction plants to centralized butadiene plants.

A second potential source of butadiene is the butane-butylene fraction of refinery cracked gases at present being produced. Increasing amounts of this fraction are being used for manufacture of alkylate for aviation gasoline and polymers for high-octane motor fuels, but the same high-temperature, low-pressure dehydrogenation methods used to convert natural-gas butanes to butadiene can be used in connection with the refinery gases including the butanes produced in crude distillation. Butadiene as such is present to a small extent in cracked gases but not to a commercial degree, though the percentage increases as cracking pressures are reduced and temperatures raised.

Finally, oil may be expressly cracked for the purpose of making butadiene as the primary product, as is understood to be the case in Standard Oil Company of Louisiana's butadiene installation at Baton Rouge. Details of the process as a whole are not available but the general principle of high-temperature, low-pressure cracking and dehydrogenation presumably is used. That there is available a sufficient amount of petroleum to make the requisite annual quantity of butadiene entirely from oil is unquestioned. Inasmuch as the expanding production of aviation gasoline is

drawing constantly more heavily on natural gas and refinery gases as a source of raw materials, specifically butanes and butenes, it looks as if more low-pressure cracking units will be required.

Equipment Needed

Additional equipment for the synthetic-rubber program will, of course, be necessary. An estimate of the precise types and quantities of equipment needed could not be made without more data than can be published under present conditions. However, from well known facts a few generalizations can be made. Furnace tubes used for cracking oil and for heating butane-butylene gases in the process of dehydrogenation are likely to be constructed largely of alloy steels, inasmuch as temperatures above 1000° F. are required. Where catalytic dehydrogenation processes are used, the catalytic reactor chambers are also maintained at high temperatures and may require alloys.

Fractionating equipment undoubtedly will figure prominently in the construction of butadiene installations. Such equipment would be needed in an expansion of natural-gasoline plants for removal of the butane cut from natural gas. In refinery operations the manufacturing process selected would determine whether or not butanes would have to be separated from butylenes in a mixture of these gases prior to making butadiene. Such separation would require fractionator towers. Finally, additional fractionation would be required to recover unreacted feed stocks in the course of manufacturing butadiene in order that such stocks may be recycled through the unit.

Compressors, power units, piping and instruments will be needed, of course, both for production of the feed stocks and for conversion of these into the product materials. Pressure storage tanks will be installed where liquid butanes and butenes have to be stored to await processing within the plant or shipment to a central processing installation.

The availability of equipment is, of course, a problem. It is this issue which has given rise to consideration of the construction of central processing plants to which liquefied raw material gases produced in small plants would be shipped by tank car, since equipment requirements per barrel of product are lower in installations of high capacity. To what degree small raw materials plants will have to be recruited in the synthetic-rubber program has not been disclosed.

Economic Considerations

From the long-range viewpoint, development of the synthetic-rubber program promises a new market for the oil industry, which year by year is expanding in the direction of chemicals production. Heretofore, the cost of natural rubber has been so much less than that of the synthetic material (roughly one third) that the synthetic-rubber market has been too small to encourage production of raw materials for rubber manufacture by the oil industry.

That situation has changed. The immediate program for synthetic rubber has been set at 400,000 tons by the middle of 1943, a quantity considered only sufficient for military purposes and a curtailed civilian demand. Not apparently considered at all is the prospect that the United States may soon be called upon to supply the rubber needs of Canada, Great Britain and perhaps Russia. Although data on current requirements of these countries are not available, the needs probably constitute a fairly large percentage of American consumption. Inasmuch as rubber consumed in the United States last year totaled about 750,000 tons, and considering the prospect that this country may be called upon to meet rubber requirements of its war allies, it certainly seems probable that the synthetic rubber industry within the next five years will have to meet a total demand much higher than 400,000 tons yearly.

That will mean intensified research to enlarge yields of raw materials for synthetic rubbers from petroleum sources. It will also mean mass production far in excess of the 12,000 tons of synthetic rubber made last year. These two developments may be depended upon to reduce materially the average present cost of synthetic rubber. Jesse Jones declared that under the 400,000-ton program the cost of synthetic rubber would be around 30 cents per pound as against 22 cents paid last year for natural rubber. The productive cost when making 750,000 pounds yearly should be less than 30 cents. The Lamp[8], Standard Oil Company (New Jersey) publication, declared in October, 1941, "As a distant goal we might look for finished synthetic rubbers at about 10 cents per pound. This prospect is better as regards Butyl rubber, for which the primary raw materials are easier to get from oil than butadiene, the needed material for Buna."

If even with large-scale production it developed that the cost of synthetic rubbers remained higher than natural rubber, the fact that the synthetic products as a class have many qualities superior to those of natural rubber, including resistance to abrasion and sunlight, will favor such products and offset any price differential that may ultimately remain.

The recent technical and commercial developments in synthetic rubber production, therefore, warrant the view that mass production of the synthetics is here to stay. If this is correct it means, of course, another large new market opening for the oil industry as a supplier of pure chemicals.

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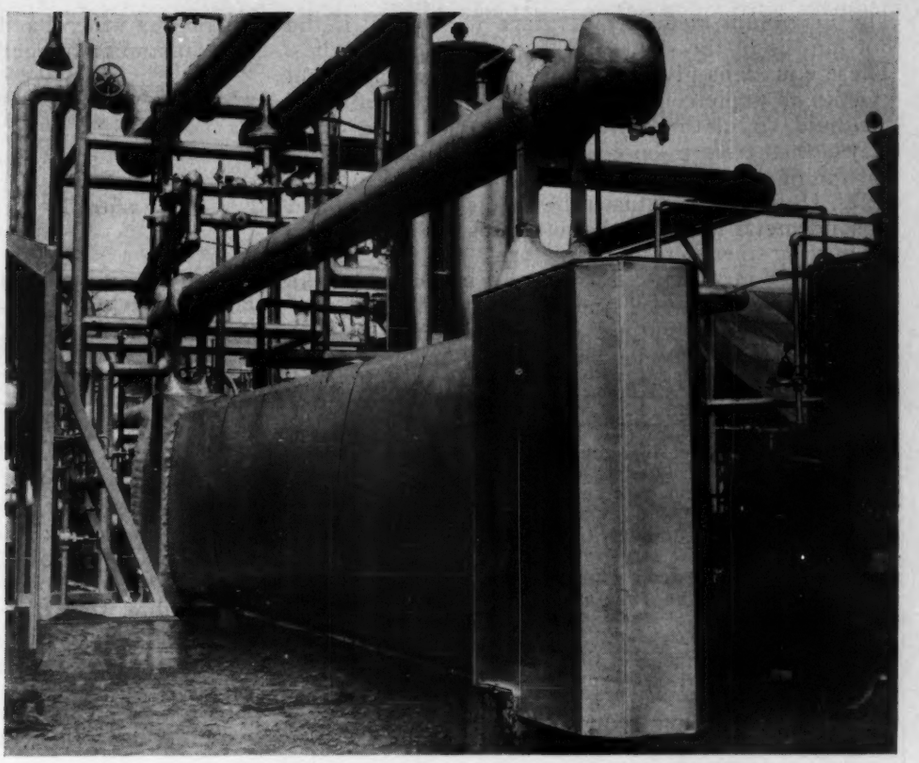

Heat Exchanger Tube Sheet Temperatures

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SINCE the permissible stress intensity of non-ferrous metals decreases rapidly with increasing temperature, considerable valuable material may be wasted by unduly cautious estimates of metal temperatures in heat exchanger tube sheets for design purposes. To provide a sound basis for reasonably accurate estimates, the author presents equations for calculating the metal temperatures in the unpierced and pierced portions of tube sheets. The derivation for the latter case is given in some detail. Examples of the use of these equations are given using as a basis the expression, $f_{max} = PR^2/L^2$; it is suggested that, if this expression is approximately correct, it is reasonable to assume that this maximum stress intensity occurs in the pierced portion of the tube sheet.

NON-FERROUS alloys, such as naval brass, Muntz metal, etc., withstand the various forms of attack by cooling water and its impurities more satisfactorily than do ordinary carbon and low-alloy steels. For this reason it is common practice to equip water-cooled heat exchangers (coolers and condensers) with brass tube sheets. These alloys, however, do not maintain their strength through as wide a temperature range as the steels; above 300° F. the allowable stress intensity of naval brass, the most frequently used tube-sheet material, falls off rapidly with increasing temperatures. Consequently, considerable valuable material may be wasted by an unduly cautious estimate of tube sheet temperatures for design purposes. It is the purpose of this paper to present a method for calculating with reasonable accuracy the metal temperatures in heat-exchanger-tube sheets.

The design temperatures for the shell and tube sides of an exchanger are specified by the prospective user and it is often assumed for design purposes that the tube sheet takes on the higher of these two temperatures. When there is any considerable difference between the design temperatures this assumption is obviously far too conservative, and this is recognized in another approximation which utilizes the heat transfer coefficients on both sides of the tube sheet:

$$T_o = T_t + \frac{(T_s - T_t)}{1 + \frac{h_t}{h_s}\left(\frac{1}{1 + h_t/h_m}\right)} \qquad (1)$$

$$T_L = T_t + \frac{(T_s - T_t)}{(1 + h_t/h_m) + h_t/h_s} \qquad (1A)$$

where T_o = metal temperature of shell side face of tube sheet.
T_L = metal temperature of tube side face of tube sheet.

The maximum metal temperature will be T_o if the hot fluid is in the shell, and T_L if it is in the tubes. These equations give the temperatures which would exist in an unpierced plate and disregard the effect of the fluid circulating through the tube holes; they may not, therefore, be considered applicable to that portion of the tube sheet which is perforated by tube holes. However, in actual tube sheets there is a band of solid metal between the outermost tubes and the supporting member and, for parts of this region sufficiently far removed from the influence of the tube holes, equations 1 and 1A are valid.

The metal temperatures of the pierced portion of the tube sheet may be obtained by means of the method derived below, in which the following assumptions are made:

1. The tube sheet ligament between adjacent tubes is thin enough compared to its length to result in a negligible temperature gradient over any cross section normal to its length.
2. The thermal conductivities of the tube wall and tube sheet metals are the same.
3. The heat transfer coefficient at the tube side face of the tube sheet is the same as the coefficient through the tubes.
4. The area through which heat flows at the shell side of the tube sheet includes the cross sectional area of the tube walls, Figure 1.

These assumptions reduce the problem to that of finding the temperature distribution in a heat transfer fin with a base area, a, length, L, surface, $(A + a)$, and conductivity, k, surrounded by a fluid at temperature, T_t, to or from which heat is transferred at a coefficient, h_t. This problem has been investigated by Harper and Brown.[4] Referring to Figure 1, the temperature, T, at any distance, x, from the shell side face of the tube sheet is given by

$$T = T_t + C_1 \sinh K\left(\frac{x}{L}\right) + C_2 \cosh K\left(\frac{x}{L}\right) \qquad (2)$$

$$\text{where } K = \sqrt{\frac{A}{a}\frac{h_t L}{k}} \qquad (3)$$

C_1 and C_2 = arbitrary constants

When $x = 0$, $T = T_o$ and $d(T - T_t)/dx = -\frac{h_s}{k}(T_s - T_o)$;

when $x = L$, $T = T_L$ and $d(T - T_t)/dx = -\frac{h_t}{k}(T_L - T_t)$.

Upon substitution of these boundary conditions and simplifying, equation 2 becomes

$$T = T_t + (T_s - T_t)\left[\frac{\cosh K\left(\frac{x}{L}\right) - \frac{Ka}{A}\eta \sinh K\left(\frac{x}{L}\right)}{1 + \eta\frac{h_t}{h_s}}\right] \qquad (4)$$

$$\text{where } \eta = \frac{A}{aK}\left[\frac{1 + \frac{A}{aK}\tanh K}{\frac{A}{aK} + \tanh K}\right] \qquad (5)$$

The symbol, η, represents the "fin effectiveness" of the tube sheet ligament, i.e., the ratio of heat transferred through it to that which would be transferred through its base area if it were not present.

If the shell fluid is the hotter, the maximum metal temperature will occur when $x = 0$, and its value, from equation 4, is

$$T_o = T_t + \frac{(T_s - T_t)}{1 + \eta\frac{h_t}{h_s}} \qquad (6)$$

If, on the other hand, the hot fluid is in the tubes the maximum temperature is

$$T_L = T_t + \frac{F(T_s - T_t)}{1 + \eta\frac{h_t}{h_s}} \qquad (7)$$

$$\text{where } F = \frac{1}{\cosh K + K\frac{a}{A}\sinh K} \qquad (8)$$

The average temperature of the tube sheet is obtained from equation 4 thus:

$$T_{av} = T_t + \int_o^1 (T - T_t)\,d\left(\frac{x}{L}\right)$$

$$= T_t + (T_s - T_t)\frac{(\eta - F)}{\left(\frac{A}{a}\right)\left(1 + \eta\frac{h_t}{h_s}\right)} \qquad (9)$$

Tube sheet temperatures could readily be calculated from equations 6, 7 and 9 were it not for the relative complexity of the coefficients η and F; this difficulty is easily overcome, however, by computing their values for all probable conditions and presenting the results graphically. Figures 2 and 3 have been prepared for this purpose and show η and F as functions of two dimensionless ratios, (A/a) and (h_t/h_m), where $h_m = k/L$, the metal coefficient which would prevail if the tube sheet were a solid plate.

Location of Maximum Stresses

Equations 1 and 1A provide a method for calculating maximum metal temperatures in the unpierced portion of a tube sheet and equations 6 and 7 serve the same purpose for the part which is perforated by tube holes. The choice between these two sets of equations will depend upon whether the maximum stress intensity occurs in the pierced or unpierced portion of the tube sheet.

It is customary to design unstayed tube sheets as though they were unpierced plates on the assumption that the loss of strength due to removal of metal from the tube holes is compensated by the staying action of the tubes. The stress equations applicable to such unpierced plates may be found in most texts on the strength of materials — see, for example, Fuller and Johnston.[3] If the plate is freely supported, the maximum stress intensity occurs at the center, in compression on the high pressure face and in tension on the low pressure face; its value for circular plates is

$$f_{max} = \frac{5}{4}\frac{PR^2}{L^2} \qquad (10)$$

where Poisson's ratio is assumed to be 1/3.

If the boundary is rigidly fixed, the maximum stress intensity occurs at the periphery, in tension on the high pressure face and in compression on the low pressure face; for circular plates, its value is

$$f_{max} = \frac{3}{4}\frac{PR^2}{L^2} \qquad (11)$$

The variation of stress intensity across a diameter for these cases is shown in Figure 4. It will be noted that these curves have exactly the same shape, the only effect of removing or adding restraint at the boundary being to displace the entire curve in the vertical direction.

Actually, tube sheets with rigidly fixed edges are not found in practice; neither are tube sheets with

perfectly free edges, although the latter condition is usually more closely approximated than the former. This may be seen from a consideration of the results of applying pressure to the tube sheets of an exchanger such as that shown in Figure 5; only a slight distortion of the supporting members will suffice to remove considerable restraint from the tube sheet circumference. The stress intensity curve must therefore lie somewhere between the two full curves of Figure 4 and parallel to them.

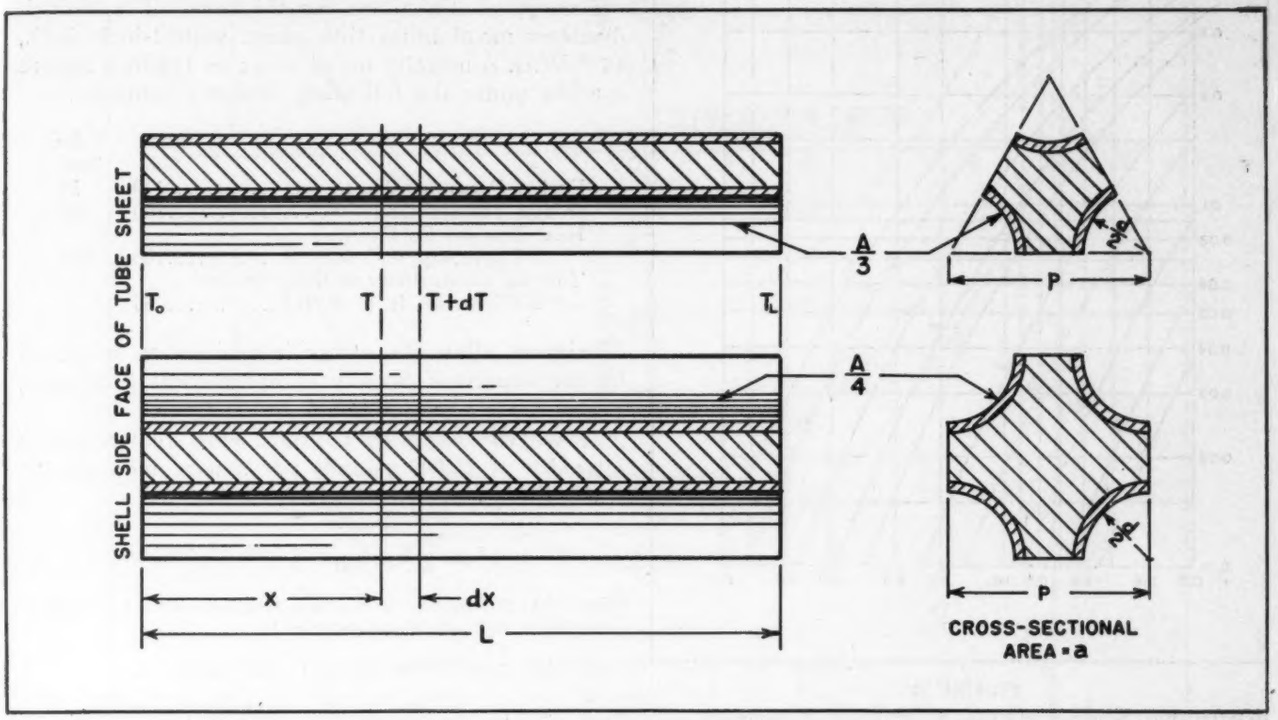


FIGURE 1
Tube Sheet Ligaments for Square Tube Spacing (below) and Triangular Spacing (above).

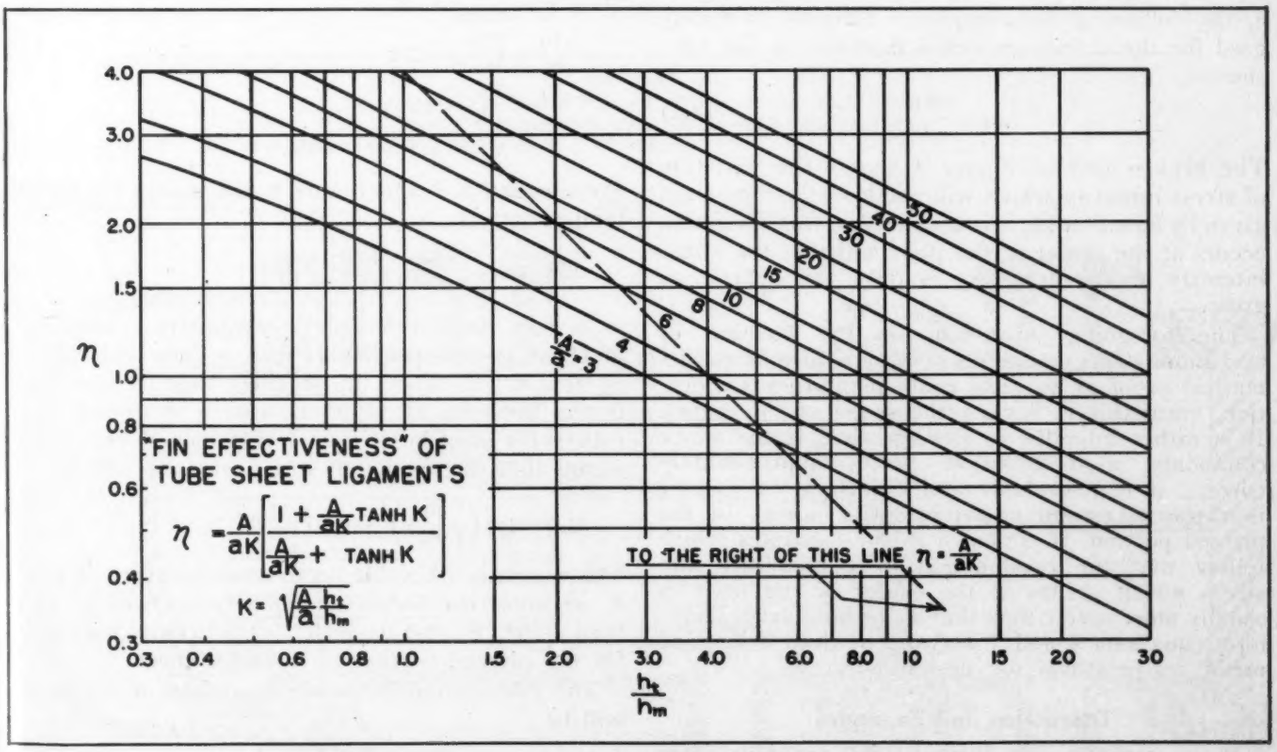


FIGURE 2
Relationship Between "Fin Effectiveness" of Tube Sheet Ligament, Physical Dimensions and Heat Transfer Coefficients.

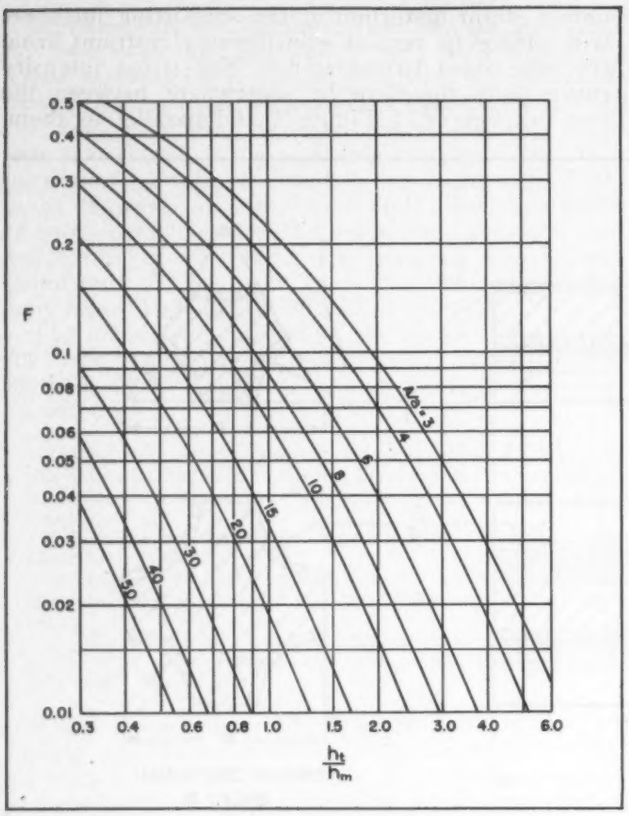


FIGURE 3
Relationship Between Factor, F, Physical Dimensions of Tube Sheet, and Heat Transfer Coefficients.

For exchangers constructed similar to that in Figure 5, the following semi-empirical formula is widely used for the maximum stress intensity in the tube sheets:

$$f_{max} = \frac{PR^2}{L^2} \qquad (12)$$

The broken line of Figure 4 shows the variation of stress intensity which will result in the maximum given by equation 12; it is evident that this maximum occurs at the center of the plate and that the stress intensity at the boundary is only one quarter as great.

The foregoing discussion on the location of maximum stress intensities is not intended as mathematical proof as to their exact magnitude or location, since this is beyond the scope of this paper. It is rather intended to indicate that, if the above commonly used equation 12 is approximately correct, it is reasonable and consistent to assume that the maximum stress intensity occurs in the pierced portion. It is shown in the examples which follow that the combination of temperature and stress which occurs at the center of the plate is usually more severe than that at the boundary; therefore, equations 6 and 7 may be used to determine metal temperatures for design purposes.

Discussion and Examples

It is, perhaps, not immediately apparent from equations 4 through 9 that the tube sheet temperatures are usually not far removed from the tube fluid temperature. This is shown in the following example which is deliberately chosen to give the maximum discrepancy between these temperatures to be expected in practice (i.e., the largest fraction of the difference between the shell and tube side design temperatures).

Example 1. Calculate the thickness of a 20-inch diameter naval brass tube sheet with 1-inch O.D., 16 B.W.G. Admiralty metal tubes on 1¼-inch square spacing under the following design conditions:

	Shell Side	Tube Side
Design Pressure—lbs./sq. in.	110	50
Design Temperature—° F.	800	100
Heat Transfer Coefficient—BTU/hr.-sq. ft.-° F.	100	250
Thermal Conductivity of Naval Brass—BTU/hr.-sq. ft.-(° F./ft.)	55	

Maximum allowable stress intensities as proposed by the American Society of Mechanical Engineers, Boiler Code Committee.[1]

It will be assumed to start with that a stress intensity of 11,000 pounds per square inch can be used; then, from equation 12,

$$L = \frac{20}{2}\sqrt{\frac{110}{11{,}000}} = 1 \text{ inch } (= 1/12 \text{ foot})$$

(Note that the higher of the two design pressures is used in accordance with the usual practice.)

$$A = \pi dL = \pi \times 0.870 \times 1 = 2.73 \text{ sq. in.}$$

$$a = p^2 - \frac{\pi}{4} d^2 = 1.5625 - .7854\ (0.87)^2 = 0.968 \text{ sq. in.}$$

$$h_m = k/L = \frac{55}{(1/12)} = 660 \text{ BTU/hr.-sq. in.-° F.}$$

Then $\frac{A}{a} = \frac{2.73}{0.968} = 2.82$

$$\frac{h_t}{h_m} = \frac{250}{660} = 0.379$$

$$\frac{h_t}{h_s} = \frac{250}{100} = 2.50$$

$$K = \sqrt{2.82 \times 0.379} = 1.034; \eta = 2.43$$

From equation 6 and Figure 2, the maximum metal temperature is

$$T_o = 100 + \frac{(800 - 100)}{1 + 2.43 \times 2.5} = 199° \text{ F.}$$

It is seen from reference[1] that a stress intensity of 11,000 pounds per square inch is permissible only up to 150° F. Since the smallest unit of variation in the thickness of plates is usually 1/16-inch, the tube sheet must be at least 1-1/16-inch thick, which means that the maximum stress intensity will be

$$f_{max} = 110\left(\frac{10}{1.0625}\right)^2 = 9730 \text{ lbs./sq. in.}$$

This stress is allowable up to a temperature of 255° F. so, since the maximum temperature will be less than 199° F., 1-1/16-inch is sufficient thickness for the pierced portion of the tube sheet.

The stress intensity at the boundary of the plate will be

$$9730/4 = 2430 \text{ lbs./sq. in.}$$

which means that the temperature of the unpierced portion may be as high as 400° F. without requiring

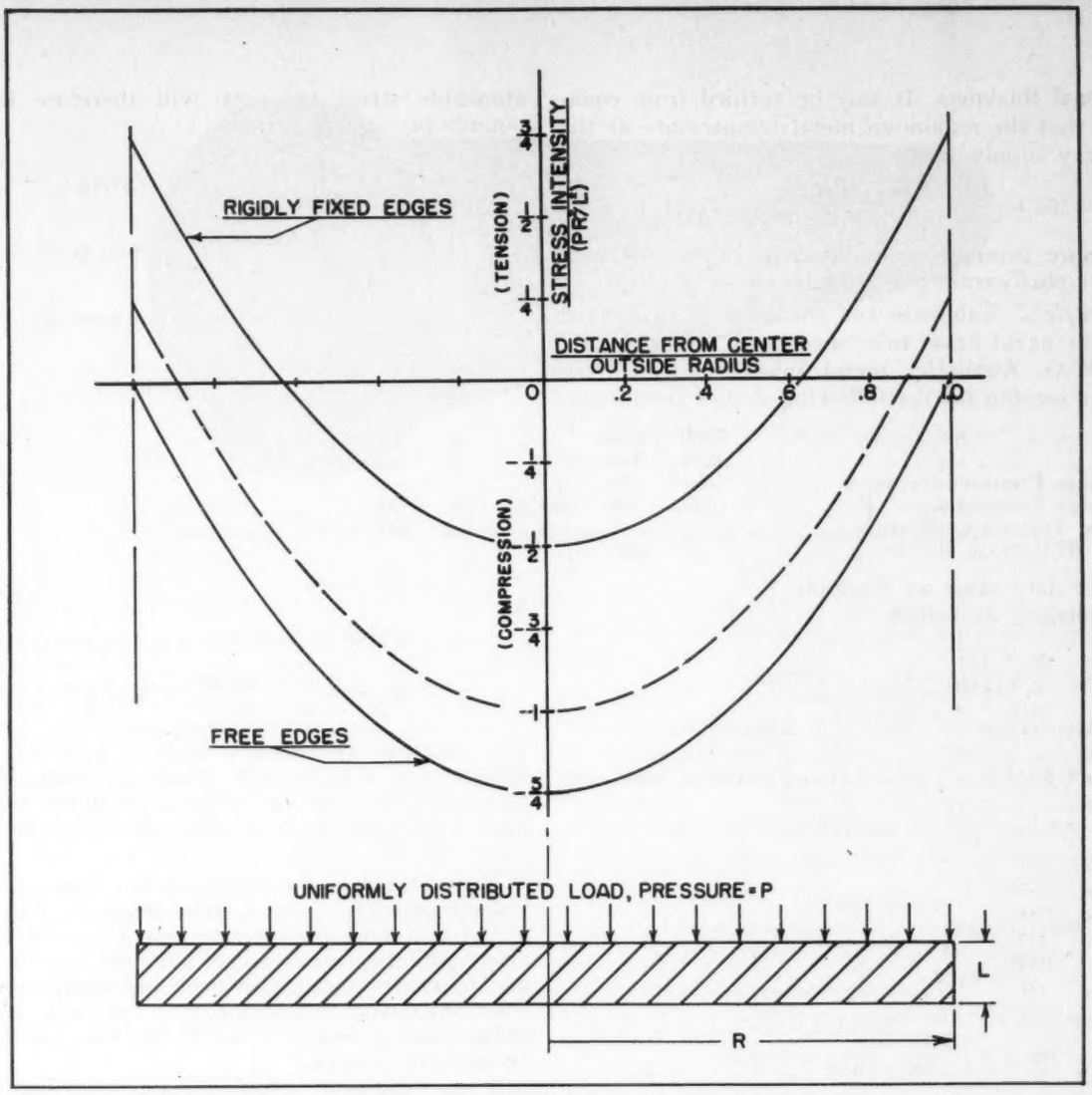


FIGURE 4
Distribution of Radial Stress Intensity at the High Pressure Face of Unpierced Circular Plates Supported at the Periphery.

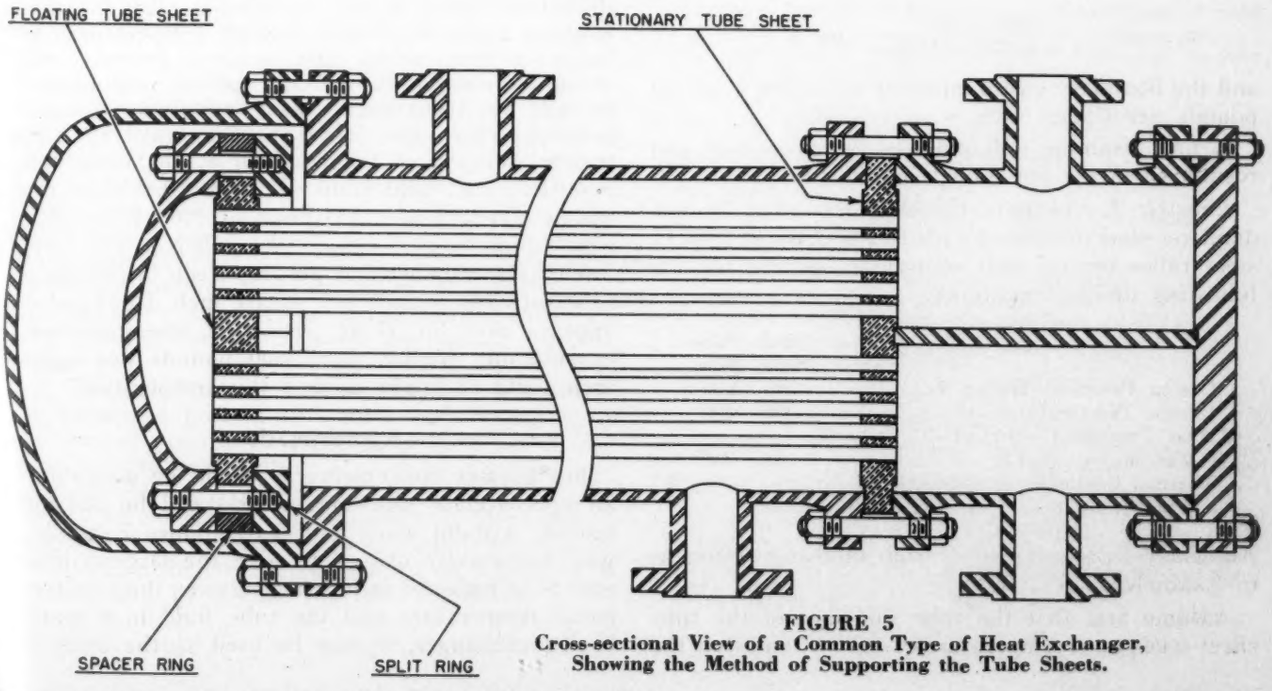


FIGURE 5
Cross-sectional View of a Common Type of Heat Exchanger, Showing the Method of Supporting the Tube Sheets.

additional thickness. It may be verified from equation 1 that the maximum metal temperature at the boundary is only

$$T_o = 100 + \frac{(800-100)}{1+2.5/(1+0.379\times 1.0625)} = 351^\circ \text{ F.}$$

A more common example with respect to heat transfer coefficients and tube layout would be:

Example 2. Calculate the thickness of a 20-inch diameter naval brass tube sheet with ¾-inch O.D., 18 B.W.G. Admiralty metal tubes on 1-inch triangular spacing for the following design conditions:

	Shell Side	Tube Side
Design Pressure—lbs./sq. in.	440	50
Design Temperature—° F.	800	100
Heat Transfer Coefficient—BTU/hr.-sq. ft.-° F.	60	1000

Other data same as Example 1.

Proceeding as before,

$$L = \frac{20}{2}\sqrt{\frac{440}{11{,}000}} = 2 \text{ in. } (= 1/6 \text{ foot})$$

$$A = \frac{\pi dL}{2} = \frac{\pi \times 0.652 \times 2}{2} = 2.05 \text{ sq. in.}$$

$$a = 0.433\, p^2 - \frac{\pi}{8} d^2 = 0.433 - \frac{\pi}{8}(0.652)^2 = 0.266 \text{ sq. in.}$$

$$h_m = k/L = \frac{55}{(1/6)} = 330 \text{ BTU/hr.-sq. ft.-° F.}$$

Then $\frac{A}{a} = \frac{2.05}{0.266} = 7.71$

$$\frac{h_t}{h_m} = \frac{1000}{330} = 3.03$$

$$\frac{h_t}{h_s} = \frac{1000}{60} = 16.67$$

$$K = \sqrt{7.71 \times 3.03} = 4.83;\ \eta = 1.595$$

$$T_o = 100 + \frac{(800-100)}{1+1.595\times 16.67} = 125^\circ \text{ F.}$$

Obviously, the original thickness is sufficient since 11,000 pounds per square inch may be used up to 150° F. For the unpierced part (boundary) of the sheet,

$$T_o = 100 + \frac{(800-100)}{1+16.67/(1+3.03)} = 236^\circ \text{ F.}$$

and the boundary stress intensity of 11,000/4 = 2750 pounds per square inch is permissible.

A final example will indicate the procedure and results when the hot fluid is in the tubes.

Example 3. Calculate the thickness of a 36-inch diameter steel tube sheet with 1-inch O.D., 14 B.W.G. steel tubes on 1¼-inch triangular spacing for the following design conditions:

	Shell Side	Tube Side
Design Pressure—lbs./sq. in.	400	600
Design Temperature—° F.	400	800
Heat Transfer Coefficient—BTU/hr.-sq. ft.-° F.	50	200
Thermal Conductivity of Steel—BTU/hr.-sq. ft.-(° F./ft.)	25	

Allowable stress intensities from the same source as in Example 1.[2]

Assume first that the tube side face of the tube sheet takes on a temperature of 800° F. and that the allowable stress intensity will therefore be 8000 pounds per square inch.

Then $L = \frac{36}{2}\sqrt{\frac{600}{8000}} = 4.925$ in., say 4-15/16 in.

$$A = \frac{\pi dL}{2} = \frac{\pi \times 0.834 \times 4.9375}{2} = 6.48 \text{ sq. in.}$$

$$a = 0.433\,(1.25)^2 - \frac{\pi}{8}(0.834)^2 = 0.406 \text{ sq. in.}$$

$$h_m = \frac{25}{(4.9375/12)} = 60.7 \text{ BTU/hr.-sq. ft.-° F.}$$

$$\frac{A}{a} = \frac{6.48}{0.406} = 15.95$$

$$\frac{h_t}{h_m} = \frac{200}{60.7} = 3.29$$

$$\frac{h_t}{h_s} = \frac{200}{50} = 4.00$$

$$K = \sqrt{15.95 \times 3.29} = 7.25;\ \eta = 2.20;\ F = 0.000982$$

$$T_L = 800 + \frac{.000982\,(400-800)}{1+4\times 2.2} = 800^\circ \text{ F.}$$

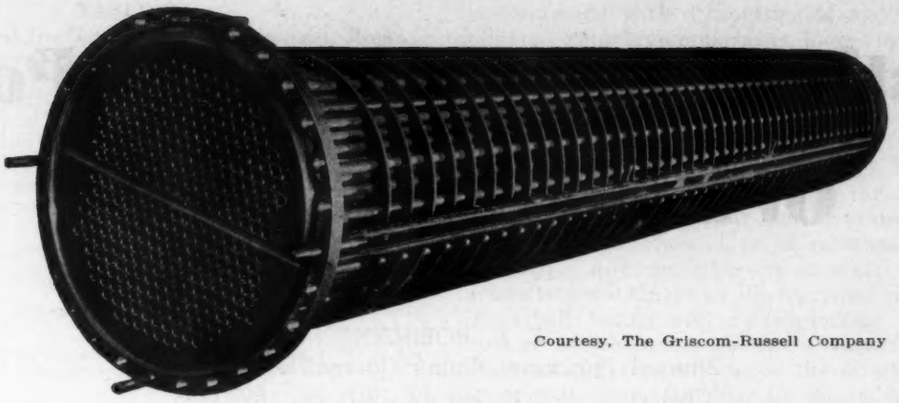
The original assumption is thus justified and a thickness of 4-15/16-inch should be used. There is no need to calculate the temperature in the unpierced part of the plate since it obviously cannot be higher than 800° F.

As indicated in the foregoing examples, it is customary practice to design tube sheets for the higher of the two fluid pressures to guard against undesirably high stress intensities if one fluid loses pressure, and to satisfy requirements of specifications. However, operating conditions may be such that the differential pressure between the two fluids could be used for design.

If the operating conditions are such that failure of cooling fluid supply could occur without loss of hot fluid pressure or temperature, consideration should be given to the strength of the tube-sheet metal at the maximum hot-fluid temperature. It should be noted in this connection that allowable working stress intensities at high temperatures are based on creep stress data, a stress intensity that would produce 0.01 percent plastic deformation (creep) in 1000 hours being relatively common practice. This value is very much lower than the tensile strength of the material at the same temperature; e.g., one source[5,6] gives the short-time tensile strength of naval brass at 400° F. as about 50,000 pounds per square inch whereas the stress intensity to produce 0.01 percent creep in 1000 hours is about 3500 pounds per square inch. It, therefore, appears that for short periods a stress intensity considerably higher than 3500 pounds per square inch could be safely used at this temperature.

Approximations

For greater convenience it would be desirable if an approximate safe-side result could be obtained quickly without using any charts. Since Example 1 was deliberately chosen to give the largest difference to be expected in practice between the maximum metal temperature and the tube fluid in a water-cooled exchanger, it may be used as the basis for



Courtesy, The Griscom-Russell Company

FIGURE 6
Heat Exchanger Tube Bundle showing stationary tube sheet with tubes on triangular layout.

a rough rule of thumb which may be stated as follows:

> The maximum metal temperature in the pierced portion of the tube sheet of a water-cooled exchanger will not exceed the sum of the tube side design temperature plus 15 percent of the difference between the two design temperatures.

A closer approximation is obtained upon observing from Figures 2 and 3 that F is usually small compared to η and that the latter has the value (A/aK), except when (A/a) and (h_t/h_m) are quite small. If it is further assumed that 1 may be neglected in comparison with η, equations 6, 7, and 9 reduce to

$$T_o = T_t + (T_s - T_t)\frac{aK}{A}\cdot\frac{h_s}{h_t} \qquad (13)$$

$$T_L = T_t \qquad (14)$$

$$T_{av} = T_t + (T_s - T_t)\frac{a}{A}\cdot\frac{h_s}{h_t} \qquad (15)$$

The maximum temperatures in Examples 1, 2, and 3 calculated by these equations become 203°, 126°, and 800° F. respectively, which agree quite satisfactorily with the 199°, 125°, and 800° F. temperatures obtained from equations 6 and 7.

Summary

1. The maximum metal temperature in the unpierced portion of a tube sheet may be found from equation 1 or 1A.

2. The maximum metal temperature in the pierced portion of a tube sheet may be calculated from equation 6 or 7; however, quite accurate safe-side results are obtained from equation 13 or 14. For water-cooled exchangers this maximum will not exceed the sum of the tube design temperature plus 15 percent of the difference between the two design temperatures.

3. The temperature variation with thickness in the unpierced portion of a tube sheet is linear; in the pierced portion it is given by equation 4. The average metal temperature is given by equation 9 or, approximately, by equation 15.

4. If the commonly used equation 12 for maximum tube sheet stress intensity is approximately correct for designs similar to that shown in Figure 5, it is reasonable to assume that this maximum occurs in the pierced part of the sheet and that the stress intensity at the periphery is only one quarter as great.

Acknowledgment

Acknowledgment is made to Joseph Price of The Griscom-Russell Company for many helpful suggestions in the preparation of this paper and for permission to publish it. The writer also wishes to thank R. O. Parker of the same company for his assistance in checking the mathematical derivations.

Nomenclature

(Any consistent set of units may be used)

A = inside surface of tubes bounding a ligament.
= πdL for square layouts.
= πdL/2 for triangular layouts.

a = $p^2 - \frac{\pi}{4}d^2$ for square layouts.

= $0.433\,p^2 - \frac{\pi}{8}d^2$ for triangular layouts.

d = inside diameter of tubes.
F = factor defined by equation 8.
f_{max} = maximum stress intensity.
h_m = k/L = metal heat transfer coefficient for unpierced plate.
h_s = heat transfer coefficient on shell side face of tube sheet.
h_t = heat transfer coefficient through tubes and on tube side face of tube sheet.

$K = \sqrt{\frac{A}{a}\frac{h_t}{h_m}}$

k = thermal conductivity of tube sheet.
L = thickness of tube sheet.
P = pressure.
p = distance between center lines of adjacent tubes.
R = mean radius of tube sheet gasket.
T = temperature.
T_{av} = average metal temperature of tube sheet.
T_o = metal temperature at shell side face.
T_L = metal temperature at tube side face.
T_s = temperature of shell fluid.
T_t = temperature of tube fluid.
η = "fin effectiveness" of tube sheet ligament.

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Investigation of the Aromatic Portion Of Light Oil Fractions*

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Translated by J. G. Tolpin
Survey of Foreign Petroleum Literature
Universal Oil Products Company

NO RELIABLE methods of determination of aromatics in lubricating oils are available because the differences between the properties of aromatics and other classes of hydrocarbons are not very pronounced in the higher-boiling oil fractions. The methods proposed for this purpose, including the use of selective solvents, hydrogenation of aromatics to naphthenes, and treatment with sulfuric acid, were evaluated in an experimental study under consideration of the available literature material. In the case of the lubricating fractions of two oils, a paraffin-base and a naphthene-base oil, it was shown that the types of aromatic compounds can be determined with a reasonable degree of probability by removing the aromatics from the oil, adding known aromatics and comparing the properties of the obtained mixtures with those of the original oil fractions. On the average, the same types of aromatic compounds were found to be present in both oils.

Notwithstanding literature references that paraffin-base oils contain aromatics with long paraffin chains, these two oils were found to contain no compounds of this type of the composition $C_{16}H_{33}$ or $C_{18}H_{37}$ in the fraction boiling at 160-200° C. and 1 mm. pressure, although one of them (Karachukhur oil) was found to contain from 12 to 14 percent aromatics and the other (Balakhany oil) 30 to 32 percent aromatics. The average composition of the aromatics in the fraction boiling at 130-160° C. and 1 mm. pressure corresponds either to dicyclic aromatics with an aliphatic chain or monocyclic aromatics containing naphthene rings in the side chain. The conclusions drawn for the fraction boiling at 190-220° C. and 1 mm. indicate the probable presence in it of either tricyclic aromatics with a paraffin chain or of dicyclic aromatics with a paraffin side chain containing one or two naphthenic rings, the total number of rings in the molecule being not less than three. Considering the constants of the hydrocarbons isolated by Rossini from Mid-Continent oil, the composition of the fraction 205-210° C. and 0.5-1.0 mm. of the two oils are also thought to be subject to the above conclusions concerning the type of aromatics present in them. Published data for other oils of different types are held to point to a similar composition.

* This translation has been submitted by the Petroleum Division of the American Chemical Society. The Petroleum Division, however, assumes no responsibility for the facts and opinions presented in this article. All data given in the original article are reported in this abstract.

Selective Solvents

Use of selective solvents is not a suitable method for determination of the chemical composition of lubricating-oil fractions. It was found in the author's laboratory[1] that while the selectivity of some solvents with respect to individual hydrocarbons of different types is quite clearly expressed, clear separation of the components of complex hydrocarbon mixtures cannot be effected by this method. The naphthene-paraffin part of the oil is partly dissolved and the aromatics removed incompletely. Repeated treatment with solvents such as levulinic acid and sulfur dioxide in benzene leaves aromatic hydrocarobns in the oil which can be removed only by sulfonation or conversion to naphthenes by hydrogenation. Rossini and co-workers[2] succeeded in removal of aromatics and naphthenes only after complicated work in which fractionation and selective solvent treatment were combined.

Hydrogenation (Ring Analysis)

This method[3,4] characterizes the oils by their ratio of aromatics and naphthenes on one hand and straight-chain compounds on the other hand. Its use

TABLE 1
Determination of Aromatic Rings in Artificial Mixtures of Aromatics, Naphthenes and Paraffins.

SOLVENT	Aromatic Hydrocarbon	Percent Aromatic Hydrocarbons	Weight Percent Aromatics Used	Weight Percent Aromatics Found	Difference, Percent
Karachukhur oil freed of aromatics, boiling at 160-170 °C. and 2 mm.	Isocetylbenzene	10.2	2.6	3.6	38
The same	Cetylbenzene	35.0	9.4	12.0	27
Heptyldecalin	Heptylnaphthalene	59.4	33.3	47.3	42
Balakhany oil freed of armoatics, boiling at 160-170 °C and 2 mm.	Diphenylhexane	36.8	23.8	25.1	5
Balakhany oil freed of armoatics, boiling at 150-160 °C and 1 mm.	Diphenylhexane	30.3	19.7	21.6	10
Dicyclohexylhexane	Diphenylhexane	39.7	25.7	28.2	9.7
Balakhany oil: 150-160 °C. and 1 mm.	Cyclohexyltetralin	25.4	9.0	15.5	72
The same	The same	59.0	20.9	33.8	60
Cycloheyxldecalin	The same	41.3	14.5	23.3	63
Heptylperhydrindene	Heptylhydrindene	81.2	23.7	48.45	104

TABLE 2

Coefficients Used for Determination of Aromatic Rings.

NAPHTHENE-PARAFFIN PART	Aromatic HYDROCARBONS	Aromatics in the Mixture		Aniline Point of the Artificial Mixture		Coefficient
		Percent Hydrocarbons	Percent Rings	Initial	After Hydrogenation	
Karachukhur oil freed of aromatics, boiling at 160-170 °C. and 2 mm...	Isocetylbenzene	10.2	2.6	94.1	98.1	0.65
The same.....	Cetylbenzene	35.0	9.4	84.1	97.4	0.65
Heptyldecalin.....	Heptylnaphthalene	59.4	33.3	17.3	72.9	0.60
Balakhany oil: 159-160 °C. and 1 mm..	Diphenylhexane	30.3	19.7	47.4	72.8	0.78
Karachukhur oil freed of aromatics, boiling at 160-170 °C. and 2 mm..	Diphenylhexane	36.8	23.8	63.4	93.0	0.80
Dicyclohexylhexane.....	Diphenylhexane	39.7	25.7	45.4	78.6	0.77
Balakhany oil freed of aromatics, boiling at 150-160 °C. and 1 mm.....	Cyclohexyltetralin	25.4	9.0	53.9	72.15	0.49
The same.....	The same	39.0	20.9	28.1	67.9	0.52
Cyclohexyldecalin.....	The same	41.3	14.5	31.1	58.5	0.53
Heptylperhdrindene.....	Heptylhydrindene	81.2	23.7	11.4	68.4	0.42
Karachukhur oil:..... 200-215 °C. and 0.2 mm.	Isocetylnaphthalene (207-210° and 0.2 mm)	18.5	6.7	95.5	103.2	0.85
Balakhany oil: 199-212 °C. and 0.5 mm.	Diisooctylnaphthalene	25.7	9.2	84.4	97.4	0.71
Hexyldecalin*.....	Hexyltetralin*	35.2	10.1	70.2	52.3	0.54

* These hydrocarbons were synthesized and placed at the disposal of the author by E. S. Pokrovskaya.

TABLE 3

Effect of Concentrated Sulfuric Acid on the Lubricating Fractions of Balakhany Oil.

Conditions of the experiment: shaking of the acid at 20° for 20-30 minutes.

BOILING RANGE OF THE FRACTION	Concentration of the Acid, Percent	Amount of Acid	Shaking Period, Minutes	Percent by Volume Aromatics Removed	n_D^{23}
140-150° (5 mm); n_D^{20} 1.4950	98	2 volumes	20	19.6	1.4755
		2 volumes	20	1.8	1.4740
		2 volumes	20	1.6	1.4740
		2 volumes	20	0	1.4740
	100.5	2 volumes	20	29.6	1.4695
		2 volumes	20	0	1.4690
		2 volumes	20	0	1.4690
		2 volumes	20	0	1.4690
190-200° (2 mm); n_D^{20} 1.5033	100.8	3 volumes	30	33.9	1.4763 1.4762

TABLE 4

Effect of Sulfuric Acid on the Lubricating Fractions of Karachukhur Oil.

BOILING RANGE OF THE FRACTION	Concentration of the Acid, Percent	Amount of Acid	Shaking Period, Minutes	Percent by Volume Aromatics Removed	n_D^{20}
160-170° (1 mm); n_D^{20} 1.4742	100.6	1 volume	30	10.82	
		1 volume	30	2.25	1.4610
		1 volume	30	0	1.4610
		1 volume	30	0	1.4605
		1 volume	30	0	1.4605
215-220° (2 mm); n_D^{20} 1.4764	100.6	3 volumes	30	14.3	1.4619 n_D^{35}
		3 volumes	30	0	1.4619 n_D
		3 volumes	30	0	1.4619

TABLE 5

Change of the Constants of the Lubricating Fractions Upon the Removal of the Aromatic Hydrocarbons.

FRACTION	Percent Aromatics Removed	Initial Fraction		After Treatment With 100.5% Sulphuric Acid			After Hydrogenation of the Dearomatized Fraction		
		Refractive Index	Aniline Point	d_4^{20}	n_D^{20}	Aniline point	d_4^{20}	n_D^{20}	Aniline Point
Karachukhur oil fraction boiling at 160-170 °C. and 1 mm.....	13.1	1.4742	87.6°	0.8356	1.4605	95.8°	0.8351	1.4605	95°
Balakhany oil fraction boiling at 158-167 °C. and 1 mm.....	32.6	1.5008	71.7	0.8688	1.4735	90	0.8676	1.4735	90

is connected with difficulties of application of complicated autoclave apparatus, long duration of experiments, insufficient knowledge of the chemistry of hydrogenation under the severe conditions used (300° C., 100-120 atm., nickel catalyst) and insufficiency of the single coefficient, 0.85, used for all cases of determination of aromatic rings by the formula $A = 0.85\ (T\text{-}T_1)$, in which T_1 is the aniline point of the oil fraction and T the aniline point of the fraction after hydrogenation. Use of mixtures of individual aromatics and naphthenes, as well as mixtures of aromatics with narrow oil fractions dearomatized as described below and hydrogenated until no more change of the constants was observed, gave the pronounced difference between the observed and actual content of aromatic rings as shown in Table 1. This difference amounts to up to 100 percent on the amount of ring compounds used. The structure of the aromatics also greatly affects the exactness of determination: heptylnaphthalene containing two aromatic rings as does diphenylhexane, however, being a fused ring compound, gave a deviation of about 42 percent, and the differences for cyclohexyltetralin and heptylhydrindene were 72 and 104 percent respectively.

The nature of the solvent is of no significance. Cyclohexyltetralin in mixture with cyclohexyldecalin (synthesized by E. S. Pokrovskaya) gave the same result as in mixture with a narrow oil fraction. The same was observed in the case of other mixtures (Table 2). The coefficient corresponding to the higher naphthalene homologs were verified using two artificial mixtures consisting in one case of isocetylnaphthalene and a narrow fraction of Karachukhur oil and in the other case of dioctylnaphthalene and a narrow fraction of Balakhany oil. For the first, the coefficient was found to be 0.85, while for the second compound, as well as for diphenylhexane, 0.75.

It follows from Table 1 that the coefficient 0.85 gives incorrect results in most cases, the exactness depending upon the nature of the aromatics. Calculation of coefficients for different individual aromatic hydrocarbons (Table 2) gave different values, almost independent of the concentration, number of cycles in the mixtures or the nature of the solvent.*

The aniline points for the artificial mixtures of the individual hydrocarbons and narrow oil fractions were determined by the method of equal volumes of the hydrocarbon and aniline.

Thus, the method of "ring analysis" is found to involve a complex, insufficiently investigated process of hydrogenation of the aromatics and an excessive inexactness of the determination of the aromatic rings, due to which the method is not suitable to analytical practice.

Sulfuric Acid Method

Sulfuric acid leaves unaffected the naphthenic and paraffinic hydrocarbons, but sulfonates fully different aromatic hydrocarbons.[1] A study of sulfonation of aromatics with long paraffin chains[5] showed that they are also sulfonated by concentrated sulfuric acid and completely removed from hydrocarbon mixtures.

The effect of sulfuric acid was studied on two Baku oils of different chemical nature, one—Karachukhur oil—being a paraffin-base oil, and the other—Balakhany oil—a naphthenic-aromatic base-oil. Treat-

* Of these hydrocarbons, cyclohexyltetralin was synthesized by E. S. Pokrovskaya; heptylnaphthalene by S. S. Nifontova; normal cetylbenzene by A. I. Blonskaya; diisooctylnaphthalene, diphenylhexane and isocetylnaphthalene were synthesized by the author.

ment with 98 percent acid did not completely remove the aromatics, but 100 percent sulfuric acid completely removed them, as shown in Tables 3 and 4. After the sulfonation, a number of narrow oil fractions were hydrogenated to verify the completeness of removal of aromatics, which is established by the data of Table 5. It is especially noteworthy that sulfonation of the fractions of both oils results in stratification, giving two layers; no third layer was formed and no coloration of the oily layer was observed. This is explained by the absence of aromatics with long paraffin chains,[5] since it was shown that compounds of this type give upon sulfonation a middle sulfuric acid layer, even when their amount does not exceed 2-4 percent of the mixture. This conclusion was further confirmed by investigation of the nature of aromatic hydrocarbons in these two oil fractions as reported below.

Concerning naphthenes and paraffins, it was found that 100 percent sulfuric acid does not affect them under the conditions used. After the aromatics added to the oil were removed, treatment with fresh portions of sulfuric acid brought about no change of the constants of the remaining oils. Similar results were obtained in the author's laboratory in treatment with 100 percent sulfuric acid of high molecular individual naphthenic hydrocarbons in which the stability of the following naphthenes to this treatment was established: dicyclohexylhexane, isocetyldecalin, diisooctyldecalin, isocetylcyclohexane, cyclopentylcyclohexane and dicyclopentylcyclohexane,[8] cyclopentyldecalin,[9] cyclohexyldecalin,[10] etc.

The results obtained in treatment of individual aromatics, naphthenes, mixtures of aromatics with the naphthene-paraffin part of the oil and treatment of initial oil fractions led to the following method of analysis of the total aromatics in oil fractions boiling at 120-220° C. and 1-2 mm. Hg pressure.

The oil is freed of all traces of unsaturated compounds by treatment with two volumes of 85 percent sulfuric acid for 30 minutes under cooling with ice, under which conditions only the unsaturated are removed, the aromatics remaining unaffected. Further, the oil is treated with 100.0 and 100.8 percent sulfuric acid by shaking with 3 volumes of acid for 30 minutes at 20° C. Additional shaking under the same conditions with a single volume of fresh acid completes the removal of aromatics. The change of the volume of the oil after the sulfuric acid treatment, calculated on the initial oil, gives the total content of aromatics in percent by volume and this can be calculated to weight percent under consideration of the specific gravity of the oil before and after removal of the aromatics. If a middle sulfuric-acid layer is formed after the sulfonation or a colored or turbid oil is observed, the unreacted oil may be recovered from the sulfonic acids by heating with aqueous alcohol.[5] The method of determination of the group composition of lubricating oil fractions,[6] involving preliminary removal of aromatics with 98-99 percent sulfuric acid, is inaccurate, since acid of a concentration lower than 100 percent removes the aromatics incompletely.

TABLE 6
Comparison of Observed and Calculated Constants of Artificial Mixtures of Oil Fractions with Individual Hydrocarbons.

MIXTURES	Per cent Aromatics	Determined Constants d_4^{20}	Determined Constants n_D^{20}	Determined Constants r	Calculated Constants d_4^{20}	Calculated Constants n_D^{20}	Calculated Constants r
Karachukhur oil, 160-170 °C. and 1 mm. Cetylbenzene	35	0.8390	1.4653	0.3297	08410.	1.4658	0.3297
Karachukhur oil, 190-200 °C. and 2 mm. Octadecylbenzene	13	0.8413	1.4649	0.3285	0.8415	1.4658	0.3289
Karachukhur oil, 150-160 °C. 0.7 mm. Heptylnaphthalene	17	0.8540	1.4755	0.3201	0.8565	1.4768	0.3298
Balakhany oil, 150-160 °C. Heptylnaphthalene	32	0.8965	1.4998	0.3279	0.8947	1.4986	0.3280
Karachukhur oil, 190-200 °C. 2 mm. and Cetylhydrindene	13.7	0.8457	1.4680	0.3287	0.8462	1.4680	0.3287
Karachukhur oil, 200-210 °C. 0.2 mm. Isocetylnaphthalene	18.4	0.8585	1.4760	0.3290	0.8580	1.4758	0.3290
Balakhany oil, 200-210 °C., 0.5 mm. Isocetylnaphthalene	28.7	0.8996	1.4990	0.3264	0.8995	1.4980	0.3257
Balakhany oil, 200-210 °C., and 2 mm. Dioctylnaphthalene	25.7	0.8859	1.4915	0.3271	0.8850	1.4923	0.3270

TABLE 7
Additivity of the Constants of the Artificial Mixtures of Aromatic Hydrocarbons with Saturated Hydrocarbons.

Composition, Percent			Found		Calculated	
Naphthenes		Aromatics	d_4^{20}	n_D^{20}	d_4^{20}	n_D^{20}
	89	11*	0.7858	1.4321	0.7894	1.4346
Cyclohexane	83	Benzene 17	0.7900	1.4352	0.7952	1.4391
	73	27	0.7976	1.4410	0.8041	1.4464
	90	10†	—	1.429	—	1.432
Methylcyclohexane	80	Toluene 20	—	1.437	—	1.440
	70	30	—	1.443	—	1.447
n-Butylcyclohexane	80	Butylbenzene 20‡	0.8106	1.4497	0.8119	1.4507
	60	40	0.8218	1.4587	0.8242	1.4607
n-Octylcyclohexane	80	Octylbenzene 20‡	0.8224	1.4571	0.8238	1.4578
	60	40	0.8303	1.4640	0.8326	1.4648
1-Methyl-2-n-propylcyclohexane	80	1-Methyl-2-n-propylbenzene 20‡	0.8186	1.4541	0.8198	1.4549
	60	40	0.8312	1.4642	0.8333	1.4641
Octahydrindene	80	Hydrindene 20‡	0.8334	1.4778	0.8861	1.4801
	60	40	0.9013	1.4913	0.9052	1.4946
Decalin	80	Tetralin 20‡	0.9000	1.4878	0.9017	1.4391
	60	40	0.9164	1.5004	0.9191	1.5021
Karachukhur Oil	86	Cetylhydrindene 14	0.8457	1.4680	0.8462	1.4680
	82	Isocetylnaphthalene 18	0.8585	1.4760	0.8580	1.4758

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Determination of the Nature of Aromatics by Ring Analysis

Experimental difficulties and inexactness of the coefficients used in this method[4] limit its applicability. It seemed to the author advantageous to determine the aromatics and the naphthenes and paraffins combined with them on the basis of the total content of aromatics and the approximate type of aromatics found in the fraction under examination. To establish the average type of aromatics present in the oil, the following method was selected. To a dearomatized oil fraction, synthetic hydrocarbons of different types were added, and the physical and chemical properties of these mixtures were compared with those of the initial fraction. A close agreement was found between the experimentally determined and calculated constants of the mixtures of synthetic aromatic compounds with oil fractions, and thus the type of aromatic compounds could be determined without actually composing the mixtures, merely on the basis of previously determined contents of aromatics in the oils under investigation and the constants of the initial and dearomatized oil fractions and the synthetic hydrocarbons. Calculation by the rule of mixing of the specific gravity and the refractive index gave data with exactness of 0.011-0.002 for the first and 0.0-0.001 for the second (Table 6). The additivity of the constants of the hydrocarbons in mixture with the naphthene-paraffin part of the

TABLE 8

Constants of Mixtures of Aromatic Hydrocarbons with Dearomatized Lubricating Fractions of Karachukhur Oil.

No.	Boiling Range of the Fraction	Individual Aromatic Hydrocarbons	Percent Aromatics in the Mixture	d_4^{20}	n_D^{20}
1	2	3	4	5	6
1	120—130°(1mm)		14	0.8500	1.4722
2		Heptylbenzene	14	0.8361	1.4625
3			13	0.8557	1.4755
4	160—170°(2mm)	n-Octylbenzene	14	0.8354	1.4618
5		n-Cetylbenzene	35	0.8390	1.4663
6			13	0.8589	1.4760
7	190—200°(2mm)	n-Octadecylbenzene	13	0.8413	1.4649
8			14	0.8500	1.4722
9	120—130°(1mm)	Heptylhydrindene	12.8	0.8426	1.4658
10			13	0.8557	1.4755
11	160—170°	Cetylhydrindene	13.7	0.8462	1.4683
12	160—170°(2mm)		13	0.8557	1.4755
13	160—170°(2mm)	Phenylhexylcyclopentane	13	0.8434	1.4671
14			13	0.8500	1.4722
15	120—130°	Cyclopentylbenzene	13	0.8471	1.4676
16			13	0.8557	1.4755
17	160—170°	Dicyclopenthylbenzene	13	0.8514	1.4707
18			13	0.8589	1.4760
19	190—200°	Tricyclopentylbenzene	13	0.8614	1.4757
20			14	0.8500	1.4722
21	120—130°	Cyclohexylbenzene	13	0.8454	1.4678
22			13	0.8557	1.4755
23	160—170°	Dicyclohexylbenzene	13	0.8510	1.4709
24			14	0.8569	1.4745
25	150—160°(1mm)	Heptylnaphthalene	17	0.8540	1.4755
26		Diphenylhexane	17	0.8515	1.4722
27			14	0.8600	1.4744
28	200—215°(0.2mm)	Diphenylhexadecane	14	0.8521	1.4695
29	200—215°(0.2mm)	Isocetylnaphthalene	16	0.8526	1.4741
			14	0.8505	
30	200—215°(0.2mm)	Diisocetylnaphthalene	14	0.8515	1.4726
31			14	0.8500	1.4722
32	120—130°(1mm)	Cyclopentylnaphthalene	14	0.8613	1.4798
33			13	0.8589	1.4760
34	190—200°(2mm)	Dicyclopentylnaphthalene	14	0.8683	1.4832
35			14	$0.8600\}^{35}_{n_D}$	$1.4744\}^{35}_{n_D}$
36	200—215°(0.2mm)	Dihydrodiisoamylanthracene	14	$0.8602\}^{n_D}$	$1.4763\}^{n_D}$

oil is observed also in the case of the lower aromatic hydrocarbons of the same structure, although in this case it is not so clearly expressed. The data shown in Table 7 reveal that with rise of the boiling temperature, the additivity increases; thus, the constants of benzene, toluene, butylbenzene and octylbenzene in mixture with saturated hydrocarbons of corresponding boiling points show a gradual increase of additivity with lengthening of the side chain. For cetylnaphthalene, the additivity is higher than for heptylnaphthalene (Tables 6, 7), and the additivity for cetylhydrindene is higher than for hydrindene.

Aromatics of Karachukhur and Balakhany Oils

The above method was applied to 10-degree fractions of the above two oils boiling within the interval of 120-220° C. at 1-2 mm. pressure. The oils were mixed with different types of aromatic hydrocarbons. The constants of the mixtures are compared in Tables 8 and 9 with the constants of the initial fractions; these tables also give constants determined as outlined above for artificial mixtures not actually composed. The aromatics were in this way investigated in fractions boiling at 120-130° C. and 1 mm. pressure, 160-170° C. and 1 mm. pressure, 190-200° C. and 1 mm. pressure and 200-210° C. and 1 mm. pressure.

The mixtures with Karachukhur oil contained heptylbenzene, isooctylbenzene (both synthesized by S. S. Nifontova), cetylbenzene and octadecylbenzene.[5] The oil fractions were of approximately the same boiling range as the hydrocarbons and the amount of aromatics used was 12-14 percent. The constants of the artificial mixtures are seen from Table 8 to show little difference from those of the dearomatized fractions, but differ sharply from the same constants of the initial oil fractions. A considerably lower specific gravity and refractive index and a high aniline point in comparison with similar constants of the initial fractions are shown by the artificial mixtures (Nos. 1-7), from which it follows that the lubricating fractions of this oil apparently contain almost no monocyclic aromatics and that the aromatics present in the oil should be of higher molecular weight, which was later confirmed.

The second group of mixtures (Nos. 8-11) also contained monocyclic aromatics with paraffin chains, but in addition, a five-member ring was also present, since these were hydrindene derivatives.[1] These mixtures containing heptylhydrindene and cetylhydrindene obviously could not be correlated with the constants of the initial fraction. The example of phenylhexylcyclopentane[7] shows that an aromatic com-

TABLE 9

Constants of Mixtures of Dearomatized Lubricating Fractions of Balakhany Oil with Individual Aromatics.

No.	Boiling Range of the Fraction	Individual Aromatic Hydrocarbons	Percent Aromatics in the Mixture	d_4^{20}	n_D^{20}
1	2	3	4	5	6
1	120—130°(1mm)		30	0.8892	1.4933
2		n-Octylbenzene	30	0.8608	1.4714
3			30	0.8997	1.4999
4	150—160°(1mm)	n-Octylbenzene	30	0.8624	1.4718
5		n-Cetylbenzene	30	0.8623	1.4739
6			32	0.9105	1.5043
7	210—220°(2mm)	n-Octadecylbenzene	30	0.8825	1.4830
8	120—130°(1mm)		30	0.8892	1.4913
9		Heptylhydrindene	30	0.8776	1.4807
10	210—220°(2mm)		32	0.9105	1.5043
11		Cetylhydrindene	30	0.8797	1.4840
12	150—160°(1mm)		30	0.8997	1.4999
13		Phenylhexylcyclopentane	30	0.8808	1.4838
14	120—130°(1mm)		30	0.8892	1.4933
15		Cyclopentylbenzene	30	0.8800	1.4849
16	150—160°		30	0.8997	1.4999
17		Dicyclopentylbenzene	30	0.8992	1.4924
18	150—160°(1mm)	Tricyclopentylbenzene	30	0.9037	1.4928
19	120—130°		30	0.8892	1.4938
20		Cyclohexylbenzene	30	0.8840	1.4853
21	150—160°		30	0.8997	1.4999
22		Dicyclohexylbenzene	30	0.8953	1.4908
23		Diphenylhexane	32	0.8883	1.4890
24	150—160°	Heptylnaphthalene	32	0.8965	1.4998
25		Isooctylnaphthalene	30	0.8847	1.4953
26			32	0.9105	1.5043
27	210—220°(2mm)	Diphenylhexadecane	30	0.8875	1.4892
28		Diisooctylnaphthalene	26	0.8859	1.4915
29	210—220°(0.5mm)		32	0.9137	1.5042
30		Isocetylnaphthalene	29	0.8996	1.4990
31	120—130°(1mm)		30	0.8892	1.4931
32		Cyclopentylnaphthalene	30	0.9160	1.5097
33	187—192°(1.5mm)		30	0.9081	1.5033
34		Dicyclopentylnaphthalene	30	0.9267	1.5144
35	200—220°(2mm)		32	0.9105	1.5043
36		Dihydrodiisoamylanthracene	30	0.9048	1.5051

TABLE 10

Determination of the Types of Aromatics in Fractions of Karachukhur and Balakhany Oils by Comparison with Hydrocarbons Isolated by Rossini.

No.	Oil Fractions	Aromatics	Percent Aromatics in the Mixture	CONSTANTS d_4^{25}	CONSTANTS n_D^{25}
1			12	0.8659	1.4777
2	Karachukhur oil: 205° and 0.5 mm.	3 aromatic rings, naphthenic ring and paraffin chain C_8H_{11}	12	0.8813	1.4907
3		2 aromatic rings, 2 naphthenic rings, 1 paraffin chain C_7H_{15}	2	0.8728	1.4825
4		1 aromatic ring, 2 naphthenic rings, 1 paraffin chain $C_{14}H_{29}$	12	0.8599	1.4727
5			30	0.9106	1.5026
6	Balakhany oil: 210° and 1 mm.	3 aromatic rings, 1 naphthenic ring, 1 paraffin chan C_8H_{11}	30	0.937	1.526
7		2 aromatic rings, 2 naphthenic rings, 1 paraffin chain C_7H_{15}	30	0.920	1.509
8		1 aromatic ring, 2 naphthenic rings, 1 paraffin chain $C_{14}H_{29}$	30	0.894	1.490

pound with a side chain containing paraffin and naphthene elements possesses constants lower than those of the aromatics of the initial fraction (Nos. 12 and 13). Thus, all of the above mentioned aromatic hydrocarbons show little agreement with the average composition of the aromatics in the oil fractions of Karachukhur oil boiling at 120-220° C. and 1 mm. pressure.

The next type of aromatics containing, in addition to the aromatic ring, one, two or three naphthenic rings, without paraffin chains, regardless of the structure of the hydrocarbons, whether condensed or not, showed almost invariably constants close to those of the initial oil fractions. This is true for cyclopentylbenzene, dicyclopentylbenzene, and tricyclopentylbenzene,[8] somewhat less for cyclohexylbenzene and dicyclohexylbenzene[11] (Table 8, Nos. 14-23).

Dicyclic aromatics present in some lubricating oil fractions were used for the next group of artificial mixtures. They included diphenylhexane,[1] diphenylhexadecane,[12] heptylnaphthalene,[1] isocetylnaphthalene[5] and diisooctylnaphthalene.[5] The constants of the mixtures with heptylnaphthalene and diphenylhexane (Nos. 24-26) are close to those of the oil fraction. From the boiling range of the fraction, it may be concluded that it contains not diphenylhexane, but rather diphenylpentane.

The fraction of Karachukhur oil boiling at 200-215° C. and 0.5 mm. (210-225° C. and 1.5 mm.) was mixed with 16-18 percent isomers of isocetylnaphthalene; the boiling point of these hydrocarbons was close to that of the oil fractions, one of these hydrocarbons having a higher specific gravity and refractive index when mixed with the oil (Nos. 27-29), produced a mixture with constants closer to the initial oil than the other isomer. Diisooctylnaphthalene and diphenylhexadecane (Nos. 30, 31, 27 and 28) also produced pronounced deviations from the constants of the initial oil fraction. Apparently, higher homologs of naphthalene are contained in the Karachukhur oil fraction boiling at 200-210° C. and 0.5-1 mm. only in very small amounts. Dicyclic aromatics with long chains show little resemblance to the aromatics found in this fraction.

Of the polycyclic naphthene-aromatics (Nos. 32-35), cyclopentylnaphthalene and dicyclopentylnaphthalene[9] were used. These have much higher constants than the initial fraction. Aromatics with three rings of the type of anthracene[13] were found to give mixtures of considerably closer constants than those of the oil fraction and may thus be present in it (No. 36).

The general conclusions based on the above results indicate that monocyclic aromatics with paraffin chains are almost absent in the investigated oil fractions; dicyclic aromatics with paraffin chains may be present in the lower fractions; in fractions boiling over 170° C. and 1 mm. pressure, tricyclic hydrocarbons predominate. Aromatics of the oil fractions boiling at 120-220° C. and 1 mm. are close to monocyclic compounds with naphthenic rings in the side chains. Dicyclic aromatics with naphthenic rings are absent.

The same aromatic hydrocarbons were added to similar boiling lubricating oil fractions of Balakhany oil. Removal of 30-32 percent aromatics from Balakhany oil fractions with sulfuric acid was accompanied by a sharp reduction of the specific gravity (by 0.034) and refractive index (by 0.028), as well as by a corresponding increase of the aniline point (by 18.4°). Addition to dearomatized fractions of aromatics in amounts corresponding to their contents in the initial fraction raised the specific gravity and refractive index; however, the extent of approximation of the constants of these artificial mixtures to those of the initial fraction entirely depends on the type of aromatics present in the mixture.

It is seen from Table 9, Nos. 1-7, that aromatics with aliphatic chains have a specific gravity and refractive index lower than the aromatics of the initial fractions of corresponding boiling range: mixtures with octylbenzene differ in specific gravity by 0.03-0.05 and in refractive index by 0.02. Monocyclic aromatics of the type of hydrindene or cetylhydrindene apparently also differ greatly from the aromatics present in the fractions of the same boiling points. This is seen from comparison of the constants of the artificial mixtures with those of the oil fractions. For heptylhydrindene, the specific gravity differs by 0.012 and the refractive index by 0.01. For cetylhydrindene, the specific gravity differs by 0.04 and the refractive index by 0.02 (Table 9, Nos. 8-11).

TABLE 11

Constants of Lubricating Fractions and Artificial Mixtures of These Fractions with Individual Hydrocarbons.

(Oils investigated at the Grozny Petroleum Research Institute.)

No.	Mixture	OIL: Grozny Paraffin-Base d_4^{20}	Grozny Paraffin-Base n_D^{20}	Grozny Non-Paraffin d_4^{20}	Grozny Non-Paraffin n_D^{20}	Emba-Dossor d_4^{20}	Emba-Dossor n_D^{20}
1	Octadecylbenzene; fraction 400—450°	11%		37%		16%	
	I†	0.8598	1.4968	0.9111	1.5050	0.8819	1.4862
	II†	0.8414	1.4516	0.8627	1.4760	0.8616	1.4744
2	Heptylnaphthalene; fraction 300—350°	14%		33%		.....	.....
	I	0.8316	1.4643	0.8819	1.4892	.....	.....
	II	0.8301	1.4634	0.8839	1.4935	.....	.....
3	Isocetylnaphthalene; fraction 400—450°	11%		37%		16%	
	I	0.8598	1.4698	0.9111	1.5050	0.8819	1.4826
	II	0.8485	1.4571	0.8863	1.4944	0.8719	1.4829
4	Dicyclopentylbenzene; fraction 350—400°	14%		34%		16%	
	I	0.8417	1.4707	0.8960	1.4970	0.8769	1.4829
	II	0.8429	1.4680	0.9007	1.4930	0.8799	1.4834

* Approximate data.
† I—initial fraction; II—artifical mixture.

Phenylcyclohexylpentane shows still less similarity to the average composition of the aromatic part of the oil fractions (Table 9, Nos. 12 and 13). Compounds containing an aromatic ring connected with one or several five-member naphthenes show constants close to those of aromatics contained in the Balakhany oil. The same is true to some extent also of hydrocarbons added in the mixture (Table 9, Nos. 14-17).

Concerning dicyclic aromatics with paraffin chains, it is seen that the type of the aromatic compound and the length of the paraffin chain predetermine the identity of these compounds with the aromatics of the oil (Table 9, Nos. 21, 24; 26, 28, 30; 23, 26, 27).

It may thus be concluded that the average composition of the aromatics of the lubricating fractions of Balakhany oil sharply differs from the monocyclic aromatics with paraffin chains, from hydrocarbons of the type of hydrindene with aliphatic chains and of the type of phenylhexylcyclopentane. Monocyclic aromatic compounds with naphthene rings but without paraffins in the side chain are closer to the aromatics of this fraction. Similarly, an agreement is observed between the constants of naphthalene homologs (heptylnaphthalene) with the homologs of the aromatics of the initial fraction. This is not observed for the higher homologs of naphthalene and diphenyl. In the higher-boiling fractions, the presence of tricyclic aromatics of the type of anthracene (Table 9, Nos. 35 and 36) is possible. The presence of naphthalene derivatives with naphthene side chains is hardly possible, since their presence in lower-boiling fractions is also improbable (Table 9, Nos. 31-35).

The general conclusions concerning the types of aromatics are also supported by the constants of the mixtures of the aromatics isolated by Rossini from Mid-Continent oil with fractions of similar boiling points of the oils investigated in this study (Table 10). The possible presence in three other oils of aromatics of the same types is indicated by the data of Table 11.

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Fundamentals of Refinery Piping Design

PART III

Dimensions and Strength of Piping

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DESIGNERS and detailers of refinery piping systems refer constantly to catalogs for dimensions and other specifications of pipe, fittings, valves and flanges. For their convenience the scattered information most frequently needed has been concentrated here in a few pages.

Figure 1 (reprinted from the author's Design Handbook for Practical Engineers) gives more than 50 separate and useful items for steel pipe from ⅛-inch to 16 inches in diameter. Detailed dimensions for piping layouts, areas of metal, moments of inertia, radii of gyration for structural designers; volumes and surfaces for hydraulics or heat exchange problems; all essential information can be read directly from the table.

For sizes larger than 16 inches in diameter, not often encountered in practice, the catalogs must be consulted until some manufacturer compiles a continuation of this table.

Brass, copper, lead and transite pipe dimensions and specifications are given in Figures 2, 3 and 4.

Figure 5 gives the critical external pressures for pipe or cylindrical shells from 12 inches to 168 inches in diameter. For example, an 18-inch pipe with wall thickness of ⅝-inch begins to collapse at 2600 pounds external pressure per square inch. This table may be used for design of vacuum towers. For a full vacuum or approximately 15 pounds per square inch of outside pressure, multiply by factor of safety desired to obtain the critical pressure and read the wall thickness directly from the table. Assuming the safety factor to be 6 for example; $pc = 6 \times 15 = 90$; a tower 66 inches in diameter with ¼-inch wall thickness would be required (pc 91 from the table).

Figure 6 illustrates how much more dangerous the outside pressure is as compared with the inside pressure. As long as the wall thickness of the pipe is greater than 4 percent of the pipe diameter, the external and internal pressures are about the same as a cause of failure. For thinner walls the external pressure decreases rapidly.

Figure 7 presents a graphical solution of the Clavarino formula. For new or corroded piping, when the outside and inside diameters are known, the allowable pressures may be read directly or the wall thickness may be easily determined within the practical working stress limits between 3,000 and 10,000 pounds per square inch. Examples 1 and 2 illustrate the practical use of this chart.

Figure 8 gives the internal pressures for standard, extra-heavy and double-extra-heavy pipe at ordinary temperatures. At temperatures higher than 800° F. the metal subjected to stress begins to flow or creep. It elongates permanently and will not spring back to its original length when the load is removed as is the case with the elongation produced within the elastic limit.

After a certain time this elongation due to the creep reaches an unsafe limit and the tubes must be taken out of service. But the stress and time elements are not directly proportional. Doubling the stress may shorten the time factor by 10 to 30 times, therefore the safe creep stress should be determined by experiments on the material in question, duplicating as nearly as possible the working conditions expected in the actual service.

Time is a very important factor in design based on creep. There is no advantage in designing an apparatus for 100,000 hours (11 years) creep stress when the economical life expected is only 1 or 2 years.

One to 3 percent elongation is used by engineers as safe limits for creep, depending on the importance and dangers of the process.

Figures 9 and 10 give creep properties of some metals frequently used in refining processes.

Steel Pipe Data

Fig. 1.

| | | |

FIGURE 2

Brass and Copper Pipe

STANDARD PIPE SIZES

NOMINAL SIZE (Iron Pipe Size) Inches	DIAMETERS		Wall Thickness Inches	WEIGHT PER LINEAR FOOT		
	External Inches	Internal Inches		Yellow Brass Pounds	Red Brass Pounds	Copper Pounds
REGULAR						
⅛	.405	.281	.0620	.246	.253	.259
¼	.540	.375	.0825	.437	.450	.460
⅜	.675	.494	.0905	.612	.630	.643
½	.840	.625	.1075	.911	.938	.957
¾	1.050	.822	.1140	1.24	1.27	1.30
1	1.315	1.062	.1265	1.74	1.79	1.83
1¼	1.660	1.368	.1460	2.56	2.63	2.69
1½	1.900	1.600	.1500	3.04	3.13	3.20
2	2.375	2.062	.1565	4.02	4.14	4.23
2½	2.875	2.500	.1875	5.83	6.00	6.14
3	3.500	3.062	.2190	8.31	8.56	8.75
3½	4.000	3.500	.2500	10.85	11.17	11.41
4	4.500	4.000	.2500	12.29	12.66	12.94
4½	5.000	4.500	.2500	13.74	14.15	14.46
5	5.563	5.063	.2500	15.40	15.85	16.21
6	6.625	6.125	.2500	18.44	18.99	19.41
7	7.625	7.062	.2815	23.92	24.63	25.17
8	8.625	8.000	.3125	30.05	30.95	31.63
10	10.750	10.019	.3655	43.91	45.20	46.22
12	12.750	12.000	.3750	53.71	55.29	56.51
EXTRA STRONG						
⅛	.405	.205	.100	.353	.363	.371
¼	.540	.294	.123	.593	.611	.624
⅜	.675	.421	.127	.805	.829	.847
½	.840	.542	.149	1.19	1.23	1.25
¾	1.050	.736	.157	1.62	1.67	1.71
1	1.315	.951	.182	2.39	2.46	2.51
1¼	1.660	1.272	.194	3.30	3.39	3.46
1½	1.900	1.494	.203	3.99	4.10	4.19
2	2.375	1.933	.221	5.51	5.67	5.79
2½	2.875	2.315	.280	8.41	8.66	8.84
3	3.500	2.892	.304	11.24	11.57	11.82
3½	4.000	3.358	.321	13.67	14.07	14.37
4	4.500	3.818	.341	16.41	16.89	17.25
4½	5.000	4.250	.375	20.07	20.66	21.10
5	5.563	4.813	.375	22.52	23.18	23.67
6	6.625	5.751	.437	31.32	32.21	32.93
7	7.625	6.625	.500	41.23	42.43	43.34
8	8.625	7.625	.500	47.02	48.39	49.42
10	10.750	9.750	.500	59.32	61.05	62.40

Unless otherwise ordered: Unless otherwise ordered, Brass or Copper Pipe is furnished with plain ends.

When Brass Pipe is ordered, Yellow Brass will be furnished unless Red Brass is specified.

Lengths: Commercial lengths of Brass and Copper Pipe are 12 feet long. Longer lengths are made to order.

Weights: Variations from the weights given in the table shown above must be expected in practice.

Gauge tubing: Prices of seamless tubing, diameter ⅛ to 10-inch in any gauge in which the different diameters are made, will be quoted on request, for direct shipment from the mill.

FIGURE 3

Lead Pipe Sizes and Weights

The Lead Industries Association has approved a new standard of lead pipe sizes which has been adopted by the principal manufacturers as an aid to consumers. In addition to eliminating numerous variations in sizes formerly found among lead pipe manufacturers, an outstanding feature of the new standard is that all sizes of lead pipe in the A, AA and AAA classifications (or "Strong," "Extra Strong" and "Double Extra Strong") will safely withstand constant cold water pressures of 50, 75 and 100 lb. per square inch, respectively.

Classification	Safe Pressures in Lb. per Square Inch
A or S	50
AA or XS	75
AAA or XXS	100

Heretofore the safe working pressure of these classes of lead pipe has decreased as the diameter of the pipe has increased. The principal changes occur in the wall thicknesses of the sizes from 1¼ in. to 2 in. Alterations made in sizes below 1¼ in. are of minor importance and small in number, but have been made to introduce a uniformity which did not exist among the lead pipe sizes of various manufacturers. The new standard is as follows:

Lead Industries Association Standard

SIZE	Classification		Outside Diam. Inches	Weight per Foot		SIZE	Classification		Outside Diam. Inches	Weight per Foot	
Inside Diam.	East	West		Pounds	Ounces	Inside Diam.	East	West		Pounds	Ounces
⅜″	E	AQ	.520	..	8	1¼″	B	M	1.592	3	12
	D	XL	.549	..	10		A	S	1.670	4	12
	C	L	.577	..	12		AA	XS	1.765	6	..
	B	M	.631	1	..		AAA	XXS	1.889	7	12
	A	S	.725	1	8						
	AA	XS	.811	2	..	1½″	E	AQ	1.740	3	..
	AAA	XXS	.888	2	8		D	XL	1.776	3	8
							C	L	1.830	4	4
½″	E	AQ	.628	..	9		B	M	1.882	5	..
	D	XL	.666	..	12		A	S	1.984	6	8
	C	L	.712	1	..		AA	XS	2.076	8	..
	B	M	.756	1	4		AAA	XXS	2.272	11	4
	A	S	.798	1	8						
	AA	XS	.876	2	..	1¾″	D	XL	2.024	4	..
	AAA	XXS	1.012	3	..		C	L	2.086	5	..
							B	M	2.146	6	..
⅝″	E	AQ	.765	..	12		A	S	2.193	6	12
	D	XL	.803	1	..		AA	XS	2.404	10	8
	C	L	.881	1	8		AAA	XXS	2.624	14	12
	B	M	.953	2	..						
	A	S	1.019	2	8	2″	E	AQ	2.185	3	..
	AA	XS	1.082	3	..		D	XL	2.284	4	12
	AAA	XXS	1.137	3	8		C	L	2.354	6	..
							B	M	2.410	7	..
¾″	E	AQ	.906	1	..		A	S	2.503	8	12
	D	XL	.940	1	4		AA	XS	2.751	13	12
	C	L	1.006	1	12		AAA	XXS	3.008	19	8
	B	M	1.068	2	4						
	A	S	1.156	3	..	2½″	.....	.....	2.75	5	..
	AA	XS	1.212	3	8		.....	.....	3.00	10	10
	AAA	XXS	1.336	4	12						
						3″	.....	.....	3.25	6	..
1″	E	AQ	1.192	1	10		.....	.....	3.50	12	8
	D	XL	1.232	2	..						
	C	L	1.284	2	8	4″	.....	.....	4.25	7	14
	B	M	1.356	3	4		.....	.....	4.50	16	6
	A	S	1.428	4	..						
	AA	XS	1.492	4	12	5″	.....	.....	5.25	9	14
	AAA	XXS	1.596	6	..		.....	.....	5.50	20	4
1¼″	E	AQ	1.442	2	..	6″	.....	.....	6.25	11	13
	D	XL	1.486	2	8		.....	.....	6.50	24	2
	C	L	1.528	3	..						

Lead pipe in sizes and weights per running foot other than indicated made to specification.

Electrochemical Series of the Metals:

In this list each metal is electropositive to all that precede it, i.e., two metals in contact in the presence of an electrolyte form a galvanic couple which tends to cause the more electropositive to be dissolved by electrolysis:

Gold	Bismuth	Thallium	Magnesium
Platinum	Antimony	Cadmium	Calcium
Palladium	Hydrogen	Iron	Strontium
Silver	Lead	Chromium	Sodium
Mercury	Tin	Zinc	Barium
Copper	Nickel	Manganese	Potassium
Arsenic	Cobalt	Aluminum	Lithium

Influence of temperature on Brinell hardness:

	25 ° C.	100 ° C.	150 ° C.
Chemical Lead	5.3	3.6	2.6

Elastic limit 200 lb. per sq. in.

Maximum load in tension that lead will withstand for an indefinite time: 200-400 lb. per sq. in.

Ultimate tensile strength, quick test:

Soft Lead ..... 1400 to 1700 lb. per sq. in.
Chemical Lead ..... 2300 to 2800 lb. per sq. in.
Wire, hard "drawn" ..... 3130 lb. per sq. in.

TABLE FOR CALCULATING SAFE WORKING PRESSURE OF PIPE AT VARIOUS TEMPERATURES

Temperature		Equivalent Steam Gage Pressure Lb. Per Sq. In.	Maximum Allowable Fiber Stress in Lb. Per Sq. In.	
° C.	° F.		Chemical Lead	6% Antimonial Lead
20	68	..	200	400
30	86	..	190	370
40	104	..	180	340
50	122	..	172	310
60	140	..	162	280
70	158	..	153	254
80	176	..	144	222
90	194	..	136	195
100	212	0	127	165
110	230	6	118	137
120	248	14	110	110
130	266	24	100	80
140	284	37	90	50
150	302	54	80	..
247	477	535	..	0
327	621	..	0	..

The formula to be used with the above values is:

$$P = \frac{2ST}{D}$$

Where P = safe working pressure in lb. per sq. in.
S = maximum allowable fiber stress from above table.
T = thickness of pipe wall in inches.
D = internal diameter in inches.

Sometimes it is advisable to use wall thicknesses greater than those derived from the above equation for mechanical or structural reasons. Where corrosion is anticipated, it is well to provide additional wall thickness.

SOLDER COMPOSITIONS AND MELTING POINTS

	Lead	Tin	Antimony		Melting Point ° C.	Melting Point ° F.
Eutectic	37	63	..		181	358
Half and Half	50	50	..		205	401
Wiping	64-57½	35-42	0-2½	complete liquefaction	242	468
				complete solidification	181	358

CONSTANTS OF LEAD

Weight and Density:

Density—11.34-11.37 gm. per cu. cm.
Weight—0.4092 lb. per cu. in. (equivalent to)—707 lb. per cu. ft.
Sheet lead, 1 ft. sq. x $\frac{1}{16}$ in. thick weighs approximately 1 lb.
Volume of 1 lb. of cast lead—2.44 cu. in.

Thermal Data:

Melting Point—327.4° C. (621° F.)
To melt 1 lb. of lead, heating from 20° C. (68° F.) requires 7100 gm. cal. or 28.4 B.T.U.
Coefficient of linear expansion (17 to 100° C.) —.0000293 per deg. C. (equivalent to) .0000163 per deg. F.
Increase in volume from 20° C. to liquid at melting point—6.1 percent.
Decrease in volume on solidifying—3.85 percent.
Increase in volume on melting—4.01 percent.
Shrinkage on casting taken in practice as $\frac{1}{16}$—$\frac{1}{8}$ in. per ft.
Shrinkage in volume calculated from liquid at melting point to 20° C.—5.8 percent.
Linear expansion per 100° F. over a 10 ft. length —about 0.2 in.

Mechanical Constants:

Hardness, Moh's scale—1.5.
Brinnell number, 1 cm. ball, 30 sec., 100 kg. load:
Ordinary Soft Lead—3.2 to 4.5.
Chemical Lead—4.5 to 6.

FIGURE 4

Weights and Dimensions of Transite Pipe

Transite Pipe is manufactured in five pressure classes, A, B, C, D and E, with a range from 100 to 500 feet head of water or pressures from 43 to 217 pounds.

CLASS	WORKING PRESSURE LB. PER SQ. IN.	EQUIVALENT HEAD FEET OF WATER
A	43	100
B	86	200
C	130	300
D	173	400
E	217	500

The pipe is furnished in standard sizes from 3″ to 36″ diameter, inclusive. Standard lengths are 10 ft. for sizes up to 7″, and 13 ft. for pipe 8″ and larger.

The interior diameters listed in the accompanying table are full flow area with no deduction. All pipe is furnished with plain ends and the exterior of the barrel is machined on each end to receive the coupling.

Dimensions of Simplex Joints

Pipe Size, Inches	CLASS A			CLASS B			CLASS C		
	L, In.	M, In.	D, In.	L, In.	M, In.	D, In.	L, In.	M, In.	D, In.
2	7.0	3.5	4.6	7.0	3.5	5.0	7.0	3.5	5.1
2½	7.0	3.5	5.1	7.0	3.5	5.5	7.0	3.5	5.6
3	7.0	3.5	5.7	7.0	3.5	6.1	7.0	3.5	6.2
3½	7.0	3.5	6.2	7.0	3.5	6.6	7.0	3.5	6.7
4	7.0	3.5	6.8	7.0	3.5	7.2	7.0	3.5	7.3
4½	7.0	3.5	7.3	7.0	3.5	7.7	7.0	3.5	7.8
5	7.0	3.5	7.8	7.0	3.5	8.3	7.0	3.5	8.4
6	7.0	3.5	8.9	7.0	3.5	9.3	7.0	3.5	9.5
7	7.0	3.5	9.9	7.0	3.5	10.4	7.0	3.5	10.7
8	7.0	3.5	11.0	7.0	3.5	11.5	7.0	3.5	12.0
10	7.0	3.5	13.1	7.0	3.5	14.0	7.0	3.5	14.6
12	7.0	3.5	15.3	7.0	3.5	16.5	7.0	3.5	17.3
14	8.0	4.0	17.7	8.0	4.0	19.2	8.0	4.0	20.2
16	8.0	4.0	20.1	8.0	4.0	21.8	8.0	4.0	23.0
18	8.0	4.0	22.4	8.0	4.0	24.3	8.0	4.0	25.8
20	8.0	4.0	24.7	8.0	4.0	26.9	8.0	4.0	28.6
24	9.0	4.5	29.6	9.0	4.5	32.2	9.0	4.5	34.2

NOTE: The weight of one Simplex Coupling with rubber rings is approximately equal to the weight of one foot of the pipe it is to connect. Thus, a Class B 6-in. Coupling weighs 9.93 lb.

Dimensions and Approximate Weights of Transite Pressure Pipe

Pipe Size, Inches	CLASS A			CLASS B			CLASS C			CLASS D			CLASS E		
	Thickness, Inches	Outside Diameter, Inches	Weight, Lb. per Lin. Ft.	Thickness, Inches	Outside Diameter, Inches	Weight, Lb. per Lin Ft.	Thickness, Inches	Outside Diameter, Inches	Weight, Lb. per Lin. Ft.	Thickness, Inches	Outside Diameter, Inches	Weight, Lb. per Lin. Ft.	Thickness, Inches	Outside Diameter, Inches	Weight, Lb. per Lin. Ft.
2	.34	2.68	2.25	.41	2.82	2.80	.46	2.92	3.19	.50	3.00	3.54	.53	3.06	3.78
2½	.34	3.18	2.73	.41	3.32	3.33	.46	3.42	3.82	.50	3.50	4.19	.53	3.56	4.54
3	.36	3.72	3.35	.44	3.88	4.46	.49	3.98	4.82	.53	4.06	5.25	.56	4.12	5.58
3½	.36	4.22	3.94	.44	4.38	4.89	.49	4.48	5.53	.53	4.56	6.02	.56	4.62	6.37
4	.38	4.76	4.72	.47	4.94	5.94	.53	5.06	6.72	.57	5.14	7.37	.61	5.22	8.00
4½	.38	5.26	5.25	.47	5.44	6.66	.53	5.56	7.50	.57	5.64	8.22	.61	5.72	8.86
5	.40	5.80	6.08	.50	6.00	7.81	.57	6.14	9.00	.62	6.24	9.92	.66	6.32	10.60
6	.42	6.84	7.66	.54	7.08	9.93	.62	7.24	11.60	.68	7.36	12.90	.73	7.46	14.00
7	.45	7.90	9.43	.59	8.18	12.70	.68	8.36	14.90	.75	8.50	16.50	.81	8.62	17.90
8	.48	8.96	11.50	.64	9.28	15.60	.75	9.50	18.70	.84	9.68	21.20	.89	9.78	22.50
10	.53	11.06	15.70	.75	11.50	22.60	.91	11.82	28.40	1.02	12.04	31.80	1.08	12.16	33.90
12	.59	13.18	20.80	.87	13.74	31.90	1.08	14.16	39.70	1.23	14.46	45.40	1.30	14.60	48.80
14	.65	15.30	26.90	1.00	16.00	42.40	1.26	16.52	54.50	1.44	16.88	62.40	1.53	17.06	66.50
16	.72	17.44	34.10	1.14	18.28	54.50	1.44	18.88	70.20	1.65	19.30	82.20	1.76	19.52	87.70
18	.79	19.58	41.80	1.28	20.56	69.40	1.62	21.24	90.70	1.85	21.70	103.00	....	.....	.....
20	.88	21.76	51.70	1.42	22.84	85.90	1.80	23.60	111.00	2.06	24.12	128.00	....	.....	.....
24	1.05	26.10	75.00	1.69	27.38	122.00	2.15	28.30	159.00	....	.....	.....	....	.....	.....
30	1.31	32.62	115.00	2.10	34.20	191.00	2.68	35.36	249.00	....	.....	.....	....	.....	.....
36	1.57	39.14	166.00	2.52	41.04	272.00	3.21	42.42	358.00	....	.....	.....	....	.....	.....

CRITICAL EXTERNAL PRESSURE FOR CYLINDRICAL SHELLS

critical pressure $p_c = \frac{3m^2}{m^2-1} \cdot \frac{EI}{R^3}$ (in lbs/sq. inch) Wall Thickness = t, Width = 1". R = Radius $m = 4$, $I = \frac{t^3}{12}$ $E = 29{,}000{,}000$ $p_c = \frac{92{,}800{,}000}{R^3} \cdot I$

Wall thick t in.	Moment of Inertia I in.⁴	Diameter of Shell "inches"																								
		12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	132	144	156	168			
1/4	0.0013	558	165	70	35.7	20.7	11.3	8.74	6.13	4.47	3.36	2.58	2.03	1.63	1.32	1.09	0.91	0.76	0.65	0.56	0.42	0.32	0.25	0.20			
3/8	0.0044	1890	559	236	121	70	44.2	29.6	20.7	15.13	11.36	8.75	6.88	5.51	4.48	3.71	3.07	2.59	2.2	1.9	1.42	1.09	0.86	0.69			
1/2	0.0104	4472	1323	559	286	166	104	70	49	35.8	26.9	20.7	16.3	13	10.6	8.8	7.3	6.15	5.2	4.47	3.36	2.59	2.03	1.63			
5/8	0.0204		2600	1094	559	325	204	137	96	70	52.7	40.5	31.9	25.6	20.8	17.2	14.2	12	10.2	8.75	6.6	5.07	4.0	3.19			
3/4	0.0352		4472	1890	970	559	353	236	166	121	91	70	55	44	35.8	29.7	24.6	20.7	17.6	15.1	11.3	8.75	6.9	5.5			
7/8	0.0558			3000	1536	890	559	375	263	192	144	111	87.5	70	56.8	47.1	39	32.9	27.9	23.9	18	13.9	10.9	8.7			
1	0.0833			4472	2290	1325	835	559	392	286	215	166	130	104	85	70	58	49	41.7	35.8	27	20.7	16.3	13			
1 1/8	0.118				3250	1890	1182	794	559	406	305	235	184	147	120	100	82	70	59	50.6	38	29.3	23.1	18.5			
1 1/4	0.163				4472	2595	1635	1094	769	559	422	324	255	204	166	137	114	96	81.6	70	52.6	40.6	31.9	25.5			
1 3/8	0.216					3440	2165	1450	1018	743	559	430	338	270	220	182	151	127	108	93	70	53.7	42.3	33.6			
1 1/2	0.281					4472	2820	1890	1325	965	726	559	440	352	286	237	196	165	140	120	91	70	55	44			
1 5/8	0.358						3590	2406	1685	1230	925	712	559	448	364	302	250	211	179	153	115	89	70	56			
1 3/4	0.446						4472	3000	2100	1532	1150	886	700	559	455	376	312	262	223	191	144	111	87.3	70			
1 7/8	0.550							3700	2690	1890	1420	1092	860	690	559	464	385	324	275	236	177	137	107	86			
2	0.666							4472	3140	2290	1705	1325	1042	835	680	559	466	392	334	286	215	166	130	104			
2 1/4	0.95								4472	3270	2450	1890	1486	1190	968	800	664	559	475	408	307	236	186	148			
2 1/2	1.30									4472	3360	2580	2030	1630	1320	1095	910	765	650	559	420	323	254	203			
2 3/4	1.735										4472	3450	2715	2170	1765	1463	1214	1020	870	745	559	432	339	272			
3	2.25											4472	3510	2820	2290	1900	1570	1325	1125	966	726	559	440	352			
3 1/4	2.86												4472	3580	2910	2410	2000	1685	1430	1228	924	712	559	448			
3 1/2	3.575													4472	3640	3015	2500	2110	1790	1533	1154	890	700	559			
3 3/4	4.40														4472	3710	3070	2590	2200	1890	1420	1095	861	688			
4	5.34															4472	3730	3140	2670	2290	1725	1330	1045	835			
4 1/4	6.4																4472	3770	3200	2750	2070	1590	1250	1000			
4 1/2	7.60																	4472	3800	3260	2450	1890	1488	1190			
4 3/4	8.95																		4472	3840	2890	2230	1750	1400			
5	10.40																			4472	3360	2590	2030	1630			
5 1/4	12.06																				3970	3000	2350	1885			
5 1/2	13.85																				4472	3450	2710	2170			
5 3/4	15.9																					3960	3110	2490			
6	18.00																					4472	3520	2820			

FIGURE 5

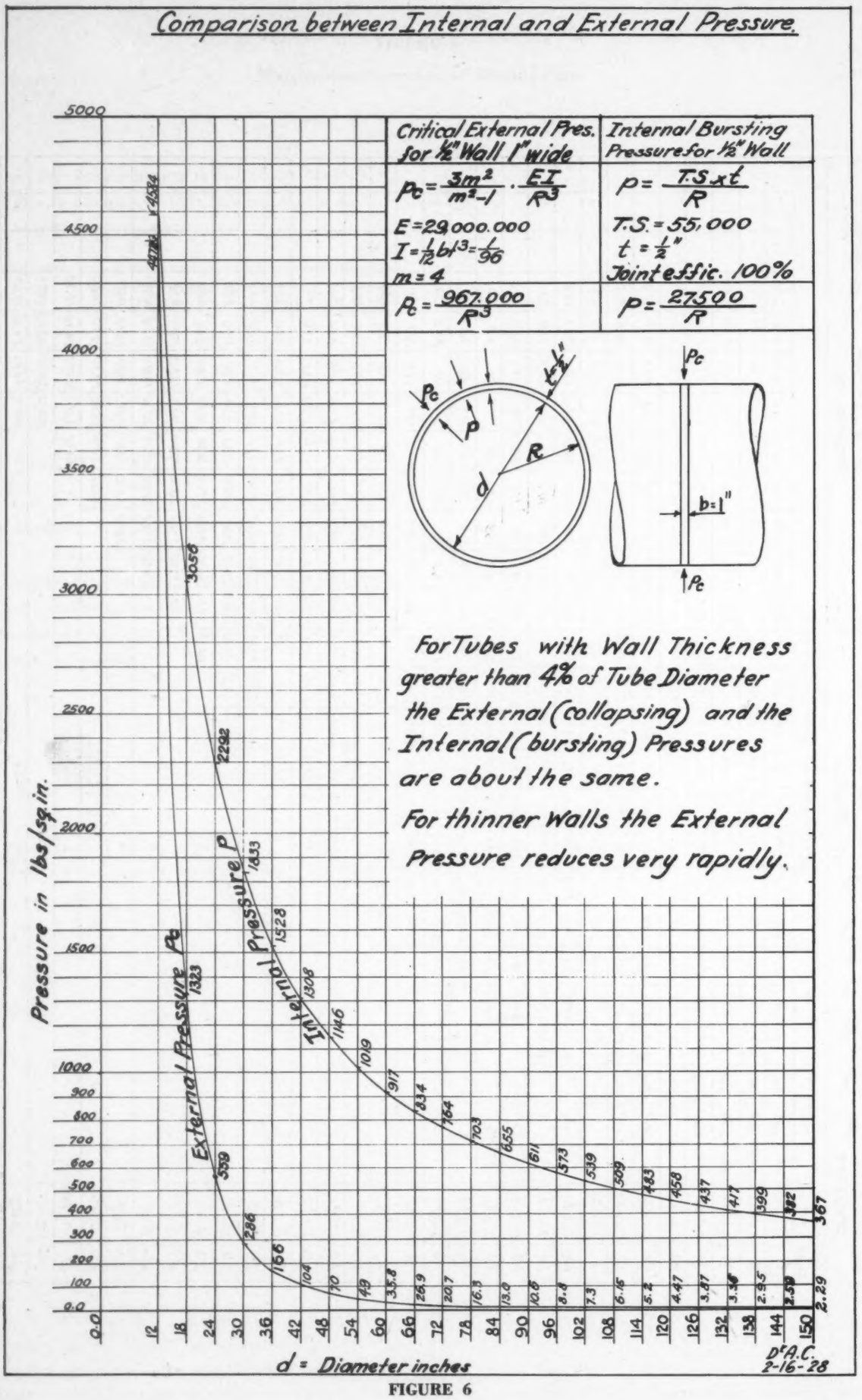
Comparison between Internal and External Pressure.
Critical External Pres. for ½" Wall 1" wide
Internal Bursting Pressure for ½" Wall
$P_c = \frac{3m^2}{m^2-1} \cdot \frac{EI}{R^3}$
E = 29,000,000
$I = \frac{1}{12}bt^3 = \frac{1}{96}$
m = 4
$P_c = \frac{967,000}{R^3}$
$p = \frac{T.S. \times t}{R}$
T.S. = 55,000
$t = \frac{1}{2}$"
Joint effic. 100%
$p = \frac{27500}{R}$
For Tubes with Wall Thickness greater than 4% of Tube Diameter the External (collapsing) and the Internal (bursting) Pressures are about the same.
For thinner Walls the External Pressure reduces very rapidly.
Pressure in lbs/sq.in.
External Pressure P_c
Internal Pressure P
d = Diameter inches
D.A.C. 2-16-28

FIGURE 6

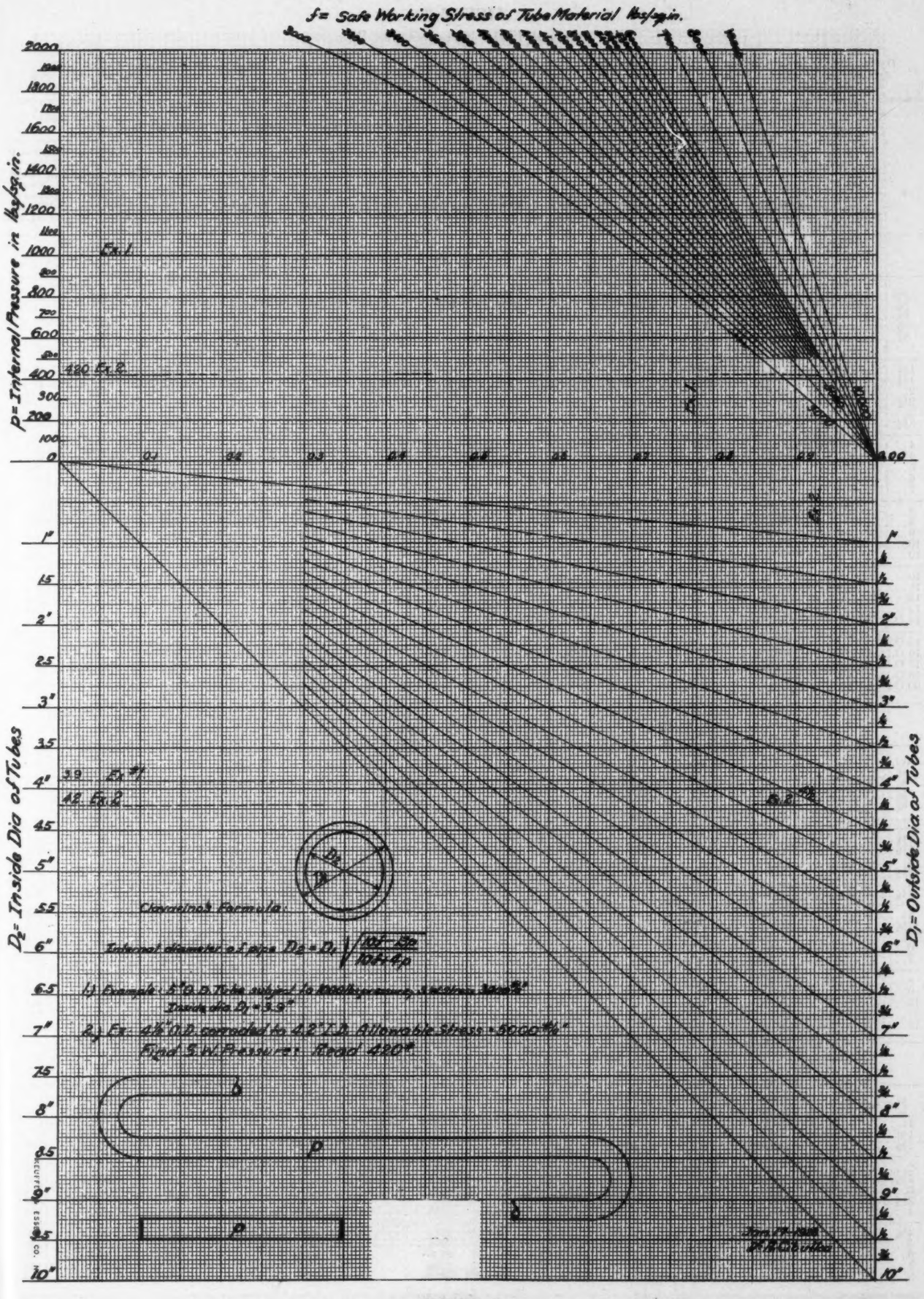
f = Safe Working Stress of Tube Material lbs/sq in.
P = Internal Pressure in lbs/sq in.
D2 = Inside Dia of Tubes
D1 = Outside Dia of Tubes
Ex. 1
420 Ex. 2
3.9 Ex. #1
4.2 Ex. 2
Clavarino's Formula:
Internal diameter of pipe D2 = D1 √((10f − 5p)/(10f + 4p))
1) Example: 5" O.D. Tube subject to 1000 lbs pressure, allowable stress 3000 lbs
Thickness D1 = 5.0"
2) Ex: 4.5" O.D. connected to 4.2" I.D. Allowable Stress = 5000 lbs
Find S.W. Pressure = ? Read 420 lbs

FIGURE 7

FIGURE 8

Internal Fluid Pressures for Pipe

D = Outside diameter in inches
t = Thickness of wall in inches.

Based on Barlow's Formula $P = 2f\frac{t}{D}$

P = Pressure in pounds per square inch.
f = Fiber stress in pounds per square inch.

SIZE	External Diameter	Thickness	ULTIMATE BURSTING PRESSURE		PRESSURES AT VARIOUS FACTORS OF SAFETY							
			Butt-weld	Lap-weld	Factor of safety=5		Factor of safety=6		Factor of safety=8		Factor of safety=10	
			Fiber Stress 40,000 Lbs. per Sq. In.	Fiber Stress 50,000 Lbs. per Sq. In.	Butt-weld Fiber Stress= 8,000 Lbs. per Sq. In.	Lap-weld Fiber Stress= 10,000 Lbs. per Sq. In.	Butt-weld Fiber Stress= 6,667 Lbs. per Sq. In.	Lap-weld Fiber Stress= 8,333 Lbs. per Sq. In.	Butt-weld Fiber Stress= 5,000 Lbs. per Sq. In.	Lap-weld Fiber Stress= 6,250 Lbs. per Sq. In.	Butt-weld Fiber Stress= 4,000 Lbs. per Sq. In.	Lap-weld Fiber Stress= 5,000 Lbs. per Sq. In.
STANDARD PIPE												
⅛	.405	.068	13432	.....	2686	.....	2239	.....	1679	.....	1343	.....
¼	.540	.088	13037	.....	2607	.....	2173	.....	1630	.....	1304	.....
⅜	675	.091	10785	.....	2157	.....	1798	.....	1348	.....	1079	.....
½	840	.109	10381	.....	2076	.....	1730	.....	1298	.....	1038	.....
¾	1.050	.113	8610	.....	1722	.....	1435	.....	1076	.....	861	.....
1	1 315	.133	8091	.....	1618	.....	1349	.....	1011	.....	809	.....
1¼	1.660	.140	6747	8434	1349	1687	1124	1406	843	1054	675	843
1½	1.900	.145	6105	7632	1221	1526	1018	1272	763	954	611	763
2	2.375	.154	5187	6484	1037	1297	865	1081	648	811	519	648
2½	2.875	.203	5649	7061	1130	1412	941	1177	706	883	565	706
3	3.500	.216	4937	6171	987	1234	823	1029	617	771	494	617
3½	4.000	.226	.....	5650	.....	1130	.....	942	.....	706	.....	565
4	4.500	.237	.....	5267	.....	1053	.....	878	.....	658	.....	527
4½	5.000	.247	.....	4940	.....	988	.....	823	.....	618	.....	494
5	5.563	.258	.....	4638	.....	928	.....	773	.....	580	.....	464
6	6.625	.280	.....	4226	.....	845	.....	704	.....	528	.....	423
7	7.625	.301	.....	3948	.....	790	.....	658	.....	493	.....	395
8	8.625	.277	.....	3212	.....	642	.....	535	.....	401	.....	321
8	8.625	.322	.....	3733	.....	747	.....	622	.....	467	.....	373
9	9.625	.342	.....	3553	.....	711	.....	592	.....	444	.....	355
10	10.750	.279	.....	2595	.....	519	.....	433	.....	324	.....	260
10	10 750	.307	.....	2856	.....	571	.....	476	.....	357	.....	286
10	10.750	.365	.....	3395	.....	679	.....	566	.....	424	.....	340
11	11.750	.375	.....	3191	.....	638	.....	532	.....	399	.....	319
12	12.750	.330	.....	2588	.....	518	.....	431	.....	324	.....	259
12	12.750	.375	.....	2941	.....	588	.....	490	.....	368	.....	294
14 O.D.	14.000	.375	.....	2679	.....	536	.....	446	.....	335	.....	268
15 O.D.	15.000	.375	.....	2500	.....	500	.....	417	.....	313	.....	250
16 O.D.	16.000	.375	.....	2344	.....	469	.....	391	.....	293	.....	234
17 O.D.	17.000	.393	.....	2312	.....	462	.....	385	.....	289	.....	231
18 O.D.	18.000	.409	.....	2272	.....	454	.....	379	.....	284	.....	227
20 O.D.	20.000	.409	.....	2045	.....	409	.....	341	.....	256	.....	205
EXTRA STRONG PIPE												
⅛	.405	.095	18765	.....	3753	.....	3128	.....	2346	.....	1877	.....
¼	.540	.119	17630	.....	3526	.....	2938	.....	2204	.....	1763	.....
⅜	.675	.126	14933	.....	2987	.....	2489	.....	1867	.....	1493	.....
½	.840	.147	14000	.....	2800	.....	2333	.....	1750	.....	1400	.....
¾	1.050	.154	11733	.....	2347	.....	1956	.....	1467	.....	1173	.....
1	1.315	.179	10890	.....	2178	.....	1815	.....	1361	.....	1089	.....
1¼	1.660	.191	9205	11506	1841	2301	1534	1918	1151	1438	920	1151
1½	1.900	.200	8421	10526	1684	2105	1404	1754	1053	1316	842	1053
2	2.375	.218	7343	9179	1469	1836	1224	1530	918	1147	734	918
2½	2.875	.276	7680	9600	1536	1920	1280	1600	960	1200	768	960
3	3.500	.300	6857	8571	1371	1714	1143	1429	857	1071	686	857
3½	4.000	.318	.....	7950	.....	1590	.....	1325	.....	994	.....	795
4	4.500	.337	.....	7489	.....	1498	.....	1248	.....	936	.....	749
4½	5.000	.355	.....	7100	.....	1420	.....	1183	.....	888	.....	710
5	5.563	.375	.....	6741	.....	1348	.....	1124	.....	843	.....	674
6	6.625	.432	.....	6521	.....	1304	.....	1087	.....	815	.....	652
7	7.625	.500	.....	6557	.....	1311	.....	1093	.....	820	.....	656
8	8.625	.500	.....	5797	.....	1159	.....	966	.....	725	.....	580
9	9 625	.500	.....	5195	.....	1039	.....	866	.....	649	.....	519
10	10.750	.500	.....	4651	.....	930	.....	775	.....	581	.....	465
11	11.750	.500	.....	4255	.....	851	.....	709	.....	532	.....	426
12	12.750	.500	.....	3922	.....	784	.....	654	.....	490	.....	392
DOUBLE EXTRA STRONG PIPE												
½	.840	.294	28000	.....	5600	.....	4667	.....	3500	.....	2800	.....
¾	1.050	.308	23467	.....	4693	.....	3911	.....	2933	.....	2347	.....
1	1.315	.358	21779	.....	4356	.....	3630	.....	2722	.....	2178	.....
1¼	1.660	.382	18410	.....	3682	.....	3068	.....	2301	.....	1841	.....
1½	1.900	.400	16842	21053	3368	4211	2807	3509	2105	2632	1684	2105
2	2.375	.436	14686	18358	2937	3672	2448	3060	1836	2295	1469	1836
2½	2.875	.552	15360	19200	3072	3840	2560	3200	1920	2400	1536	1920
3	3.500	.600	.....	17143	.....	3429	.....	2857	.....	2143	.....	1714
3½	4.000	.636	.....	15900	.....	3180	.....	2650	.....	1988	.....	1590
4	4.500	.674	.....	14978	.....	2996	.....	2496	.....	1872	.....	1498
4½	5.000	.710	.....	14200	.....	2840	.....	2367	.....	1775	.....	1420
5	5.563	.750	.....	13482	.....	2696	.....	2247	.....	1685	.....	1348
6	6.625	.864	.....	13042	.....	2608	.....	2174	.....	1630	.....	1304
7	7.625	.875	.....	11475	.....	2295	.....	1913	.....	1434	.....	1148
8	8 625	.875	.....	10145	.....	2029	.....	1691	.....	1268	.....	1014

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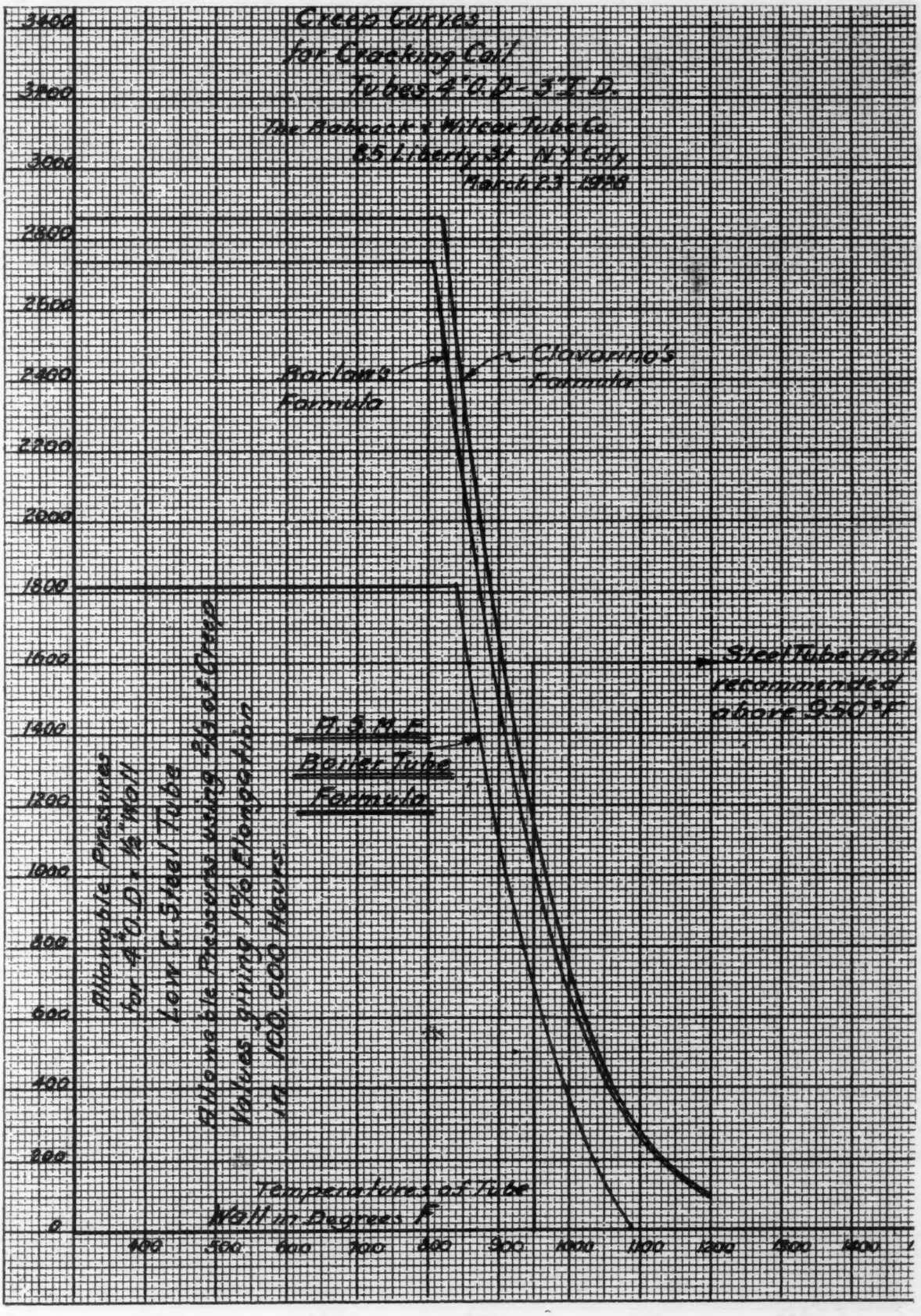
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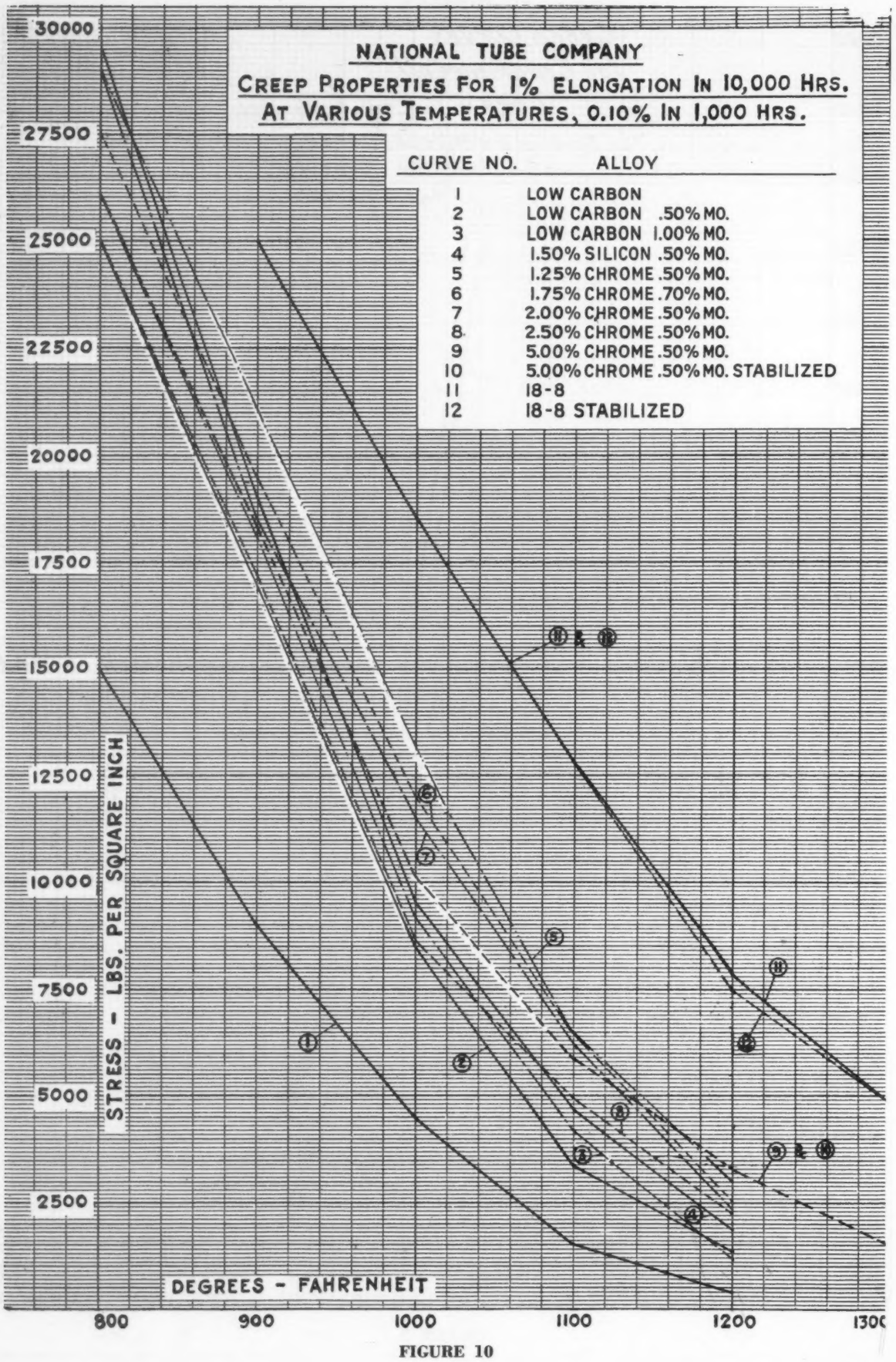
for Cracking Coil
Tubes 4" O.D.-3" I.D.
The Babcock & Wilcox Tube Co.
85 Liberty St. N.Y. City
March 23, 1938
Barlow's Formula
Clavarino's Formula
A.S.M.E. Boiler Tube Formula
Steel Tube not recommended above 950°F
Allowable pressure for 4" O.D. x .12" wall Low Steel Tube
Allowable pressure to cause 1% creep in 100,000 hours
Allowable pressure to cause 1% creep in 10,000 hours
Temperature of Tube Wall in Degrees F.
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
400
500
600
700
800
900
1000
1100
1200
1300
1400

FIGURE 9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AT VARIOUS TEMPERATURES, 0.10% IN 1,000 HRS.
CURVE NO. ALLOY
1 LOW CARBON
2 LOW CARBON .50% MO.
3 LOW CARBON 1.00% MO.
4 1.50% SILICON .50% MO.
5 1.25% CHROME .50% MO.
6 1.75% CHROME .70% MO.
7 2.00% CHROME .50% MO.
8 2.50% CHROME .50% MO.
9 5.00% CHROME .50% MO.
10 5.00% CHROME .50% MO. STABILIZED
11 18-8
12 18-8 STABILIZED
30000
27500
25000
22500
20000
17500
15000
12500
10000
7500
5000
2500
STRESS - LBS. PER SQUARE INCH
800
900
1000
1100
1200
DEGREES - FAHRENHEIT

FIGURE 10

TURNING THE SPOTLIGHT ON ARSENIC

REVERE POINTS THE WAY TO BETTER CONDENSER TUBES

● A few hundredths of one per cent of arsenic introduced into Revere Admiralty condenser tube alloy has proved effective in preventing dezincification. This effectiveness has been demonstrated by Revere Arsenical Admiralty tubes in commercial installations. It is borne out by British practice. And it has now been verified further by a new series of laboratory tests described in a paper presented before a recent meeting of the American Society for Testing Materials.

Not only do these tests confirm that the addition of as little as 0.03% arsenic supresses dezincification of alpha brass alloys such as Admiralty metal—but they show that it does so without impairment of the alloy in other essential respects.

The author, Mr. W. Lynes, Research Metallurgist in the Revere Laboratories, states his conclusions as follows:

"Laboratory tests indicate that dezincification of alpha brass alloys may be effectively suppressed by a small addition (for example, 0.03 per cent) of arsenic, antimony or phosphorus, without impairment of the alloys in other respects. These results have been confirmed, especially in the case of arsenic, by extensive service experience."

This paper has been considered of such value that it was reprinted in full, without solicitation, by "Metal Industry", one of the leading British technical magazines. The general subject of condenser tube corrosion is of such vital and universal interest that Revere has reprinted the paper so that every engineer can be fully informed on the latest advances in condenser tube alloys.

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Little Chance of Overcoming East Coast Shortage

ALTHOUGH shipment of petroleum into the East Coast area by tank car, barge and pipe line is expected to continue to rise, there is no indication that sufficient oil can be moved to completely offset the tanker situation. Consequently, stocks on the East Coast should continue to decrease, and curtailment of consumption apparently is almost unavoidable. The decision to regulate deliveries of fuel oils in the district strengthens this view.

Continuation of declines in stocks of the East Coast, further tightening of the tanker situation and indications that the volume moving by water to the area will decline as additional boats are sunk and diverted to the West Coast, has again focussed attention on use of tank car and pipe line as a means of offsetting the tanker shortage.

Greater Tank Car Use

The outlook for increased shipments of crude and refined products into District 1 by tank car is good. Such movements have been rising steadily to new peaks in recent weeks. In the week ended February 21, 10,162 tank cars moved into the area shipments averaging 326,636 barrels daily; whereas 7987 cars brought in 256,725 daily the week before, and 6935 cars brought 222,975 daily in the February 7 week. About 65 percent of the oil involved was crude.

Efficiency of tank-car handling, it has been pointed out by District 1 transportation officials, has been improved materially; loaded cars standing two days on sidings and in refineries are no longer the rule. It is declared that with further improvements and greater usage of tank cars, the volume of crude and products that can be brought into the district should reach 350,000 barrels daily if traffic congestion is avoided and sufficient locomotives are available. Ickes has stated it is possible railroads may operate under a cargo priority system to increase the use of tank cars.

With respect to pipe-line deliveries, authorities declare that as far as refined products are concerned the volume has been rather small but will soon expand with beginning of regular deliveries by the Plantation and Southeastern pipe line systems. A Plantation official declared two weeks ago that tank cars began taking 20,000 barrels of refined products daily from the end of the line at Greensboro, South Carolina, for trans-shipment to Eastern Seaboard points. When all pump stations are in operation, this line will have a capacity of 60,000 barrels per day, but much of this will be removed at points along the route. The capacity of Southeastern pipe line is 30,000 barrels per day. Both of these lines will release tank cars for moving petroleum into the Eastern area. It has been learned from transportation committee of District 1 that by the middle of March, about 64,000 barrels per day of refined products will be entering District 1 by pipe lines, and that pipe-line consignments of crude should be at least 65,000 barrels per day.

General Situation

However, there seems to be little prospect that a large proportion of East Coast oil requirements can be met by tank cars and pipe lines in the near future. Tank cars apparently will not bring in much over 350,000 barrels per day, crude shipments of pipe lines evidently will be about 70,000 barrels, and at best transportation of refined products by pipe lines will total around 90,000 barrels daily. Shipments by barge are under 100,000 barrels daily.

The sum of these totals is 600,000 barrels per day, or 36 percent of the 1,650,000 barrels per day needed to fill requirements. With a score of tankers already sunk and others to be attacked, plus the diversion of boats to the West Coast and others to be diverted, this sum is not sufficient to offset tanker losses. In addition, tanker movements are being delayed by the submarine attacks, and probably will have to depend upon slow convoy system before long.

Depletion of East Coast inventories when stocks already were abnormally low and disrupted shipments indicate the gravity of the situation.

The Office of Petroleum Coordinator has approved a plan for regulating deliveries of fuel oils. The plan limits fuel deliveries to resellers and consumers to prevent hoarding. OPC also is urging tankers to carry fuel oil, so there will be sufficient supply for industrial needs; which means civilian motorists will suffer.

Ickes called for a voluntary cut of 15 percent in civilian gasoline consumption. If the current appeal for voluntary action fails, rationing is considered unavoidable.

Eastern Needs Desperate

Seriousness of the shortage of petroleum products, particularly fuel oils, on the East Coast was emphasized during the past week by an SOS call from a major company for both light and heavy fuel oils from the Southwest and by moves made in the latter, supplying region for increasing overland movement of oils.

From New York, W. S. Farish, president of Standard Oil Company (New Jersey), telegraphed all refiners of fuel oil as far west as Nebraska, Kansas, and Texas seeking supplies of kerosene, range oil, No. 2 heating oil, and Bunker C or No. 6 fuel oil, of which, he explained, "we are in desperate need." He added that refiners could quote prices on loaded tank cars for delivery in 30 or 60 days or offer oil for which his company would furnish the cars. The move was described as an effort to avoid rationing in the East in the early future.

Congestion in Southwest

While suppliers of the East Coast were gravely concerned over the ability to continue meeting demand

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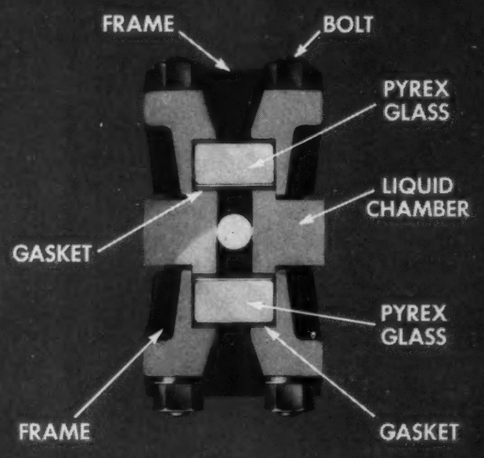
TRANSPARENT

LIQUID LEVEL GAGES

To observe the color or density of liquids under high pressures and/or temperatures



Made of alloy temperature resisting steel. Liquid chamber for single or multiple section gage is made of a solid block of steel the full width of frame to assure perfect alignment and rigidity. Frame has an extra heavy beam at each end and glass chamber is accurately machined to the contour of the glass providing full metal backing for the gaskets. Pyrex glass has greater resistance to thermal shock and erosion.

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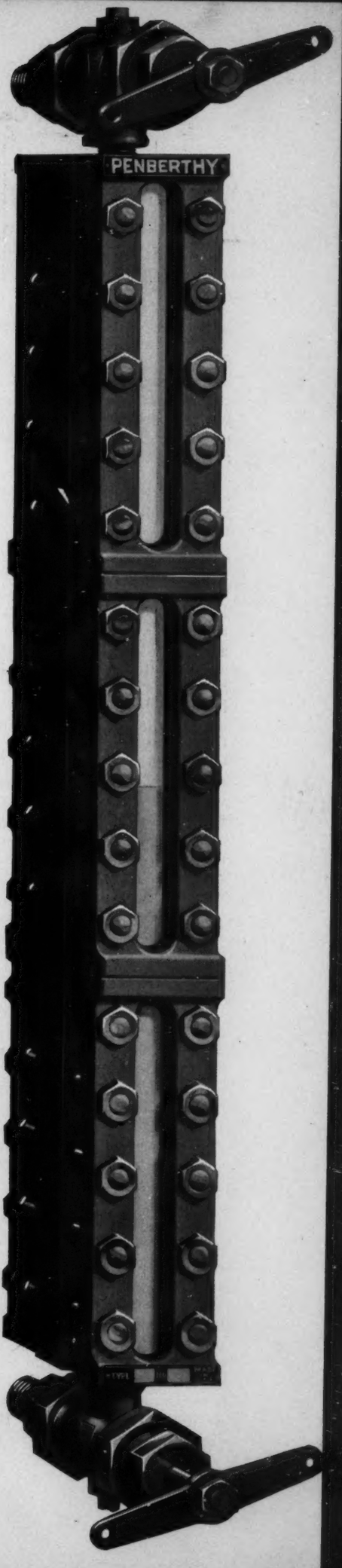

PENBERTHY INJECTOR COMPANY

DETROIT, MICHIGAN

THOS. PENBERTHY PRODUCTS

CANADIAN PLANT:
WINDSOR, ONTARIO

Weekly East Coast Refining and Stock Trends

Week Ending	Refinery Runs, Daily Average	Gasoline Production	Stocks of Finished & Unfinished Gasoline	STOCKS OF FUEL OIL			
				Gas Oil & Dist. Fuels	Residual Fuel	Total Stocks	Percent of January 3 Stocks
Jan. 3.....	668,000	2,000,000	20,118,000	19,132,000	11,933,000	31,065,000	100.0
10.....	603,000	1,685,000	19,863,000	17,728,000	11,053,000	28,781,000	92.7
17.....	565,000	1,644,000	20,361,000	15,742,000	10,109,000	25,851,000	83.2
24.....	603,000	1,700,000	19,812,000	14,207,000	9,615,000	23,822,000	76.8
31.....	618,000	1,820,000	19,536,000	13,400,000	8,789,000	22,189,000	71.4
Feb. 7.....	583,000	1,715,000	19,343,000	12,756,000	8,573,000	21,329,000	68.7
14.....	513,000	1,419,000	19,317,000	10,328,000	8,586,000	18,914,000	61.0

Figures from American Petroleum Institute. Stocks of fuel oils, at refineries, bulk terminals and in pipe lines.

for petroleum products, producers and refiners of the Southwest became increasingly conscious of the tanker shortage through backing up of crude oil and finished materials on the Gulf Coast and through shrinkage of demand for crude in some of the inland producing areas that feed their output into the Gulf-Atlantic movement.

In consequence of the transportation shortage and resultant piling up of stocks on the Gulf Coast, Humble Oil & Refining Company reduced purchases of West Texas and New Mexico crudes 40 percent and cut takings by 50 percent in Southwest Texas fields yielding high-gravity low-octane crude. Independent refiners of the Gulf Coast have been similarly affected. One refinery owner shut down his plant at Houston, because storage was filled, pending arrival of tankers to provide relief, and several other refiners said they would be forced to shut down shortly for lack of storage unless tankers arrived promptly to move products that had been sold but not lifted. Practically all of the independent refiners of the Gulf Coast expected to reduce their crude purchases in March because of refined products filling storage. The situation was recognized by OPC, Bureau of Mines, and Texas Railroad Commission, and was reflected in OPC's lowering of recommended production rates for March in Texas, Louisiana, and New Mexico, and in reduction of allowables by the state conservation authorities of Texas and New Mexico.

Committee Works on Problem

To work immediately on the increasingly serious problem of bolstering movement of oils from the Southwest to the East, five pipe line company executives were appointed as a special sub-committee of the Transportation Committee of District 3, Office of Petroleum Coordinator, the group having been designated by H. C. Wiess, of Houston, chairman of the transportation committee and president of Humble Oil & Refining Company, as a subcommittee on emergency supply. The subcommittee was asked to go into session in Houston February 25 and to make a preliminary progress report by the end of the week. Its membership included: T. E. Swigart, of Houston, president of Shell Pipe Line Company, as chairman; Charles Fitzgerald, of Fort Worth, Sinclair Refining Company; B. E. Hull, of Houston, president of Texas Pipe Line Company; J. L. Latimer, of Dallas, Magnolia Pipe Line Company; and G. L. Rowsey, of Taylor, Taylor Refining Company. The subcommittee was asked to recommend procedures by which the transportation needs of District 3 could be met as efficiently as possible, with minimum use of new materials, and by which crude oil and products could be moved as effectively as possible toward the East Coast.

The subcommittee was advised to consider utilization of existing pipe lines in such manner as to serve most effectively the essential refineries, terminals, and producing areas. And it was pointed out that this might involve such unusual measures as (1) moving some existing pipe lines for use elsewhere or (2) the conversion of gas lines to oil lines for emergency movement. The subcommittee also was advised to consider the necessity of eliminating cross-hauls by tankers and barges and to free as much of this equipment as possible for movement east.

The other subcommittee of the Transportation Committee of District 3 appointed by Wiess was that on tankers, composed of J. H. Wood, Jr., of Dallas, Atlantic Pipe Line Company, chairman; Maston Nixon, of Corpus Christi, Southern Minerals Corporation; and R. W. Pack, of Beaumont, Sun Pipe Line Company. The group was due to meet in Washington on February 26 with H. A. Gilbert, director of transportation in the Office of Petroleum Coordinator, and with members of the Tanker Coordinating Board to study the tanker situation. The tankers subcommittee was instructed to give special consideration to needs of all Gulf Coast refiners, especially those supplying defense products. It is to include in its report recommendations for meeting the needs of such refiners and to advise whether in its opinion allocation of tankers should be employed, and if so, the best method of establishing allocations, in order that this matter might be presented to the National Transportation Committee and the Petroleum Industry War Council on March 2 and 3, and subsequently to the Petroleum Coordinator. The subcommittee was asked to indicate how the Transportation Committee of District 3 might best discharge its duties in the matter.

Dig Up Texas Lines?

Two proposals for alleviating the East Coast oil shortage were particularly in the limelight last week, although numerous others also were generally discussed. They were: (1) digging up some of the lines between East Texas and the Gulf Coast for use in building a line eastward, and (2) conversion of some natural gas lines of the Southwest and Southeast into oil lines.

The first of those proposals was advocated by Jerry Sadler, member of the Texas Railroad Commission, who said that 14 East Texas-Gulf Coast lines were in operation and that some could be moved, while capacity of others could be pooled to maintain movements to the coast.

"Convert Gas Lines to Oil"

The proposal to make use of existing gas lines for handling oil was believed in some quarters to have important possibilities although engineers familiar with operation of both oil and gas lines doubted if it would be found practicable to undertake conversion of lines upon a large scale. Meanwhile, no investigation of practical value had been made as to the economic and technical problems that would be involved in the suggested falling back on existing gas lines for help in alleviating the East Coast oil shortage.

In suggesting that gas lines might afford help, it was stated that perhaps some of the parallel gas lines between Southwest Texas and the Texas Gulf Coast and East

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There's less flow resistance and pressure loss when you use Tube-Turn welding fittings

A flashing glide down the mountain side into a splendidly executed *Kristiana*—a sweeping turn at full speed that scarcely slows the skier! It's the same kind of uninterrupted flow that engineers desire in piping—and TUBE-TURN welding elbows and returns assure minimum resistance, thanks to the easy sweeping radius throughout. TUBE-TURN fittings' smooth inner walls are free from waves, scales or ridges which often accelerate corrosion and erosion. TUBE-TURN fittings give *plus strength* where the danger lies—at the turns—wherever there is a change *in flow direction!* For safe, trouble-free piping systems, insist on TUBE-TURN welding fittings!

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Welding Fittings

Texas might be converted to oil, and that capacity of remaining lines might be stepped up by addition of compressors, and that greater use might be made locally of gas from Gulf Coast and Southwest Texas fields. Similarly, it was suggested that some of the gas lines leading across Louisiana and Mississippi into Tennessee, Alabama, and Georgia, perhaps might be used for carrying oil on eastward, and that industries in those areas could revert to coal. It was conceded, however, that some of the industries of the Southeast might have disposed of their coal burning equipment, and information was lacking as to the extent to which those industries engage in war production. Attention was called to the fact that gas companies are connected into numerous fields from which they take only comparatively small volumes of gas, and it was said capacities of main gas lines are not fully utilized. But representatives of gas companies who were contacted said it was necessary to be connected to numerous fields in order to take care of seasonal and occasional heavy loads, with demand fluctuating widely. Likewise, they stated, trunk lines must have large capacities available at all times, although the full capacity is not constantly used.

In the speculations, it was assumed that cutting off of gas from some, if not numerous, domestic consumers would be unavoidable, but that wood, coal, kerosene, and other fuels could be substituted. However, gas men warned that much trouble would arise from such disruption of domestic fuel set-ups, affecting many homes, and requiring new cooking and heating equipment.

Several engineers of oil and gas pipe line companies were questioned as to the mechanical practicability of using gas lines for service in oil pipe line systems, and they cited two major obstacles that would be involved. (1) Most of the gas lines are low pressure, they said, and those lines could not be operated at the pressures of 800 or 900 pounds which are common in operation of oil lines. Walls of the gas lines are relatively thinner, valves are lighter, and many of the gas lines have rubber couplings that make them undesirable for handling oil. In contrast with the gas lines, oil lines must be able to withstand higher pressures, as handling of a fluid involves pulsations from pumps and a hammering effect when valves are turned, whereas gas lines are not subjected to such sharp jumps and drops in pressures. Furthermore, it was stated, many of the gas lines if dug up for use elsewhere would be found corroded and pitted and especially undesirable for use in oil pipe line systems. (2) The other major difficulty of converting gas lines into oil lines, it was stated, would be the necessity of substituting pumps, tanks, and other scarce equipment and materials instead of the compressor stations used in handling gas; although the oil industry doubtless is not making maximum use of the pumps and tanks that it has.

Probably the greatest possibility for stepping up overland movement of oil to the East, in the opinion of some oil industry executives, is that of legislative dissipation of all the fears of anti-trust prosecution that still make oil men hesitate to act in concert in handling the transportation problem, as brought out in the recent hearings of the Cole commitee, some of the things that the petroleum coordinator is finding necessary or desirable for the industry to do in the emergency are authorized by OPC and the Department of Justice but yet the powers of those administrative agencies to make such authorization are not set forth in laws enacted by Congress. Consequently, both the petroleum coordinator and the oil industry are in the position of having the anti-trust laws hanging over their heads, despite action in accordance with the obvious wishes of Congress and the people. Better coordination of the industry's facilities could be achieved, it is contended, if the oil companies were specifically and clearly exempted by Congress from some of the provisions of the anti-monopoly laws.

Gasoline a By-Product

The prospect that gasoline will under military requirements of crude oil become a by-product was made clear in the outline of petroleum requirements by the War Production Board to the Interstate Commerce Committee of the House of Representatives last month. Aviation gasoline, butadiene, toluene and aviation lubricants are essential products. These can not be had until crude oil has been through the processing which involves, gasoline, kerosine and fuel oil.

Thus it seems that the staples must be made regardless of demand, while the specialties determine throughput to refining plants. The viewpoint of WPB on this subject is:

"The current demand for domestic crude-oil production is close to 4,100,000 barrels per day which amounts to nearly 1,500,000,000 barrels per year. Because a large portion of the products from this volume of crude finds its way into civilian uses not directly related to the war program, it is not widely understood that much of the production is necessary to supply the constituents of the four petroleum products considered to be of greatest direct importance to the war program; namely, (a) aviation gasoline, (b) aviation lubricants, (c) toluene, and (d) synthetic rubber.

"It has been estimated that nearly 2,600,000 barrels per day of crude will be needed to produce the requirements of these essential products for this year. With the completion of additional units in 1943 for the manufacture of the four critical petroleum products, the crude requirements will mount to almost 3,600,000 barrels per day, or over 1,300,000,000 barrels per year, which is equal to 88 percent of the current volume of production. This quantity of crude will be required irrespective of the demand for ordinary petroleum products such as motor gasoline and fuel oil, which would in effect be produced as by-products of the four critical military products. It therefore becomes apparent that any possible curtailment of civilian consumption of gasoline or fuel oil would have a relatively small effect upon crude-oil requirements.

"There has been much loose talk of the possibilities of reducing crude-oil requirements by restricting so-called non-essential civilian consumption of motor fuel. While admitting that some non-essential uses of gasoline could be eliminated without serious consequences, yet there exists considerable doubt as to the extent to which civilian consumption of motor fuel could be limited without jeopardizing essential industrial activity. It is believed that essential needs for petroleum will actually increase beyond the current level of production. The controlling factor in the matter will be fuel oil, and, irrespective of the effects of the rubber or automobile shortages or of possible artificial curtailment on motor fuel consumption, the essential needs for fuel oil will likely require the maintenance of crude-oil production at or above the current level. The crux of the matter is simply that limitation of crude-oil production through restriction of gasoline consumption would seriously affect the supply of fuel oil, for, with the essential requirements of other products, fuel oil yields can be shifted only moderately, probably a maximum of 5 percent on the total volume. The supply of fuel oil is "tight" at this time, and any substantial restriction in use would soon raise other important problems concerning critical materials and would also seriously affect essential industrial operations.

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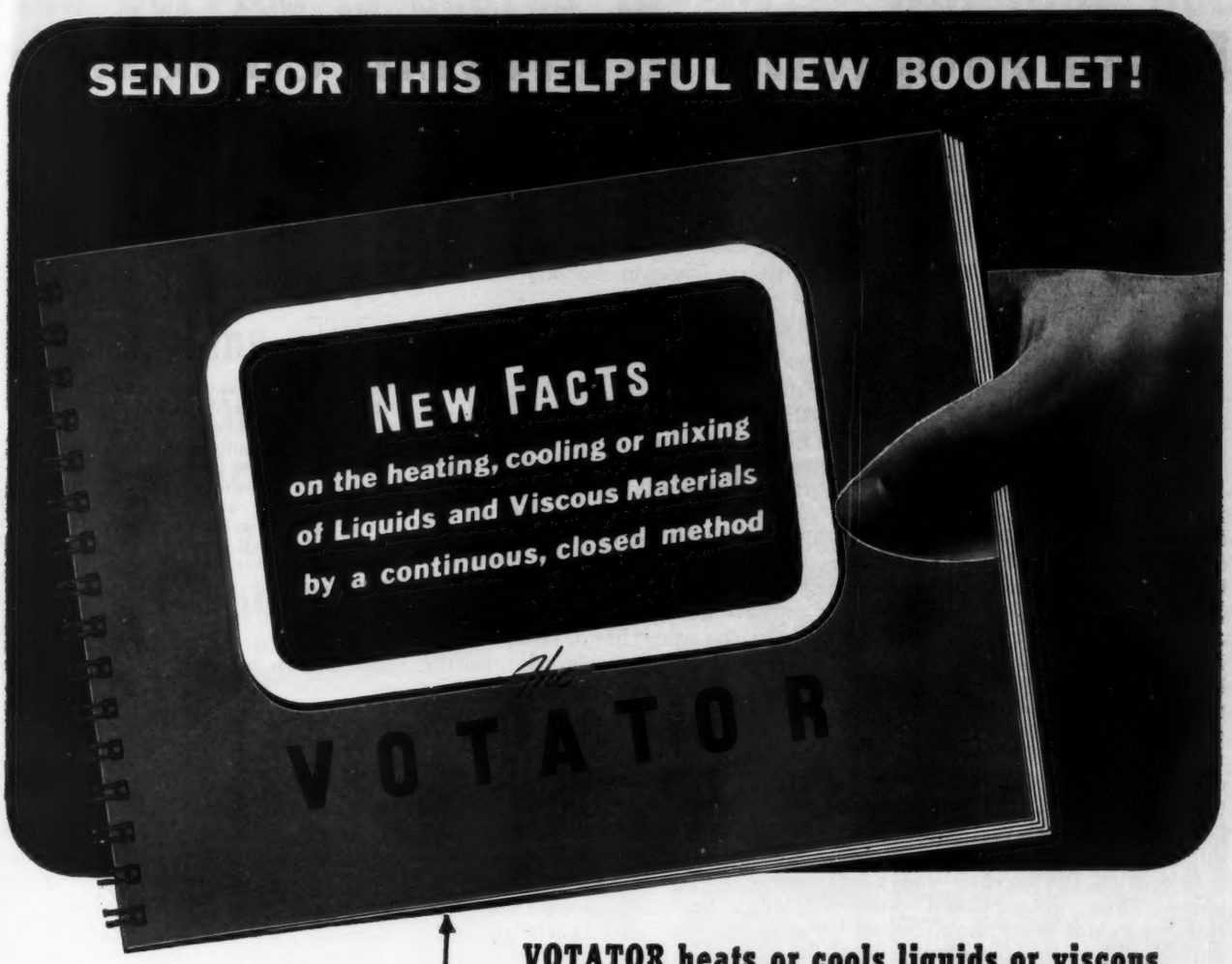

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Paint Programs to Prevent Corrosion And Evaporation Losses

PAUL L. LOTZ*
Socony Paint Products Division, Socony-Vacuum Oil Company
New York

ALL METALS corrode when placed in an unfavorable environment. Iron, which is used to the greatest extent in our present economy, is unfortunately the most susceptible to corrosion under average conditions. Corrosion is generally defined as "a gradual wearing away or distintegration by a chemical process, as in the rusting of iron." In the oxygen and water environment of this world we live in, the surfaces of our steel structures are slowly oxidized and converted to hydrated iron oxide which is evidenced by its reddish color commonly known as rust. In this process the iron must first enter into solution in the adherent moisture film before chemical reaction with the oxygen can take place. Thus, in corrosion, something does not enter the metal and corrode it as is commonly supposed. The metal goes out or dissolves, takes on an electrical charge, becomes reactive, and combines with oxygen. With many metals this formation of a film of metallic oxide is protective and stops or greatly retards further solution. With iron, however, the formation of the oxide film does not exercise an inhibitive action—it actually stimulates corrosion.

It has been well established that the process of corrosion is initially electrolytic in character. Slight differences in electrical potential on the steel surface are caused by impurities in the metal, differences in crystal structure, strain areas and particles of sand, cinders or dust. Thus there are established, between these dissimilar areas, numerous small galvanic cells. Between the numerous anodic and cathodic areas there is a flow of electrical current through the connecting electrolytic paths furnished by the surface moisture. The extent of the resulting corrosive action is proportional to the quantity of current flow which, in turn, is influenced by the conductivity of the moisture film. In coastal regions moisture carries saline impurities which increase conductivity and promote rapid corrosion. In industrial areas the acidic gases, sulphur dioxide and carbon dioxide, which are present in relatively high proportions, have a similar accelerating action.

On the other hand, certain soluble materials introduced into the moisture film inhibit corrosion. For instance, soluble chromates bring about a condition known as passivity. This favorable condition is understood to be caused by the formation of a complex, tightly adherent surface film, resulting from the chemical action of the chromate radical on the iron. The steel surface has been altered and now exhibits the characteristics of a more noble metal in its resistance to solution and oxidation. The corrosion rate can also be decreased by a reduction in acidity (hydrogen ion concentration) which may be brought about by the introduction of soluble basic materials in the contacting moisture.

Loss in structural steel due to corrosion annually approaches astronomical figures. It has been stated by one authority that it would reach a sum equivalent to one third of the cost of our federal government in normal times. To combat this loss, organic coating materials such as paints, lacquers, enamels, pitches, and asphalts, are employed. It has been reliably estimated that 1,000,000 gallons of paint are consumed every three days for corrosion prevention.

What, then, can the paint technologist, structural steel engineer, and maintenance engineer do to minimize corrosion losses and adequately and economically protect out investment in tankage and other steel equipment? The ideal paint system we suggest would include the following qualities:

1. The required fluidity to permit proper application.
2. Adequate wetting qualities toward the steel surface combined with the required persistence of fluidity for a period of time sufficient to permit complete wetting of the steel and the formation of a continuous film.
3. Sufficient and adequate thickness to insure the required quantity of protective material.
4. Reasonable drying speed to insure the formation of the stabilized dried coating within a practical, allowable time limit.
5. Complete impermeability to water and oxygen in order to prevent these necessary elements in corrosion from reaching the reactive steel surface.
6. Permanency to the effects of sun and weather and other destructive agencies.

It is evident to all that this perfect paint system has not been achieved and that the best paint system is lacking, to a certain degree, in many of the requirements of this theoretically ideal system. In approaching this problem we must appreciate its magnitude and in so doing we realize the difficulty of producing a single paint that would perform all of the requirements. We therefore simplify our approach by dividing the problem.

Surface Preparation

It can be readily appreciated that the steel surface requires some attention in order to insure a reasonably clean, continuous foundation to receive the initial coat of paint. Paint must wet the steel surface completely in order to accomplish the required bonding and produce a continuous coating. Rust, loose mill scale, grease, oil, and other foreign material that prevents the paint from reaching the steel will interfere with proper bonding and must be removed. All fabricated steel produced by hot rolling is coated with a thin layer of iron oxide known as mill scale. It differs in composition and in electrical properties and, as one would expect, offers an ideal galvanic combination with the steel for the formation of the galvanic cells referred to previously. This mill scale, when tight and continuous, offers excellent protection. We

* Before the Spring meeting of the Southwestern District of The American Petroleum Institute, Dallas, February 27 and 28, 1942.

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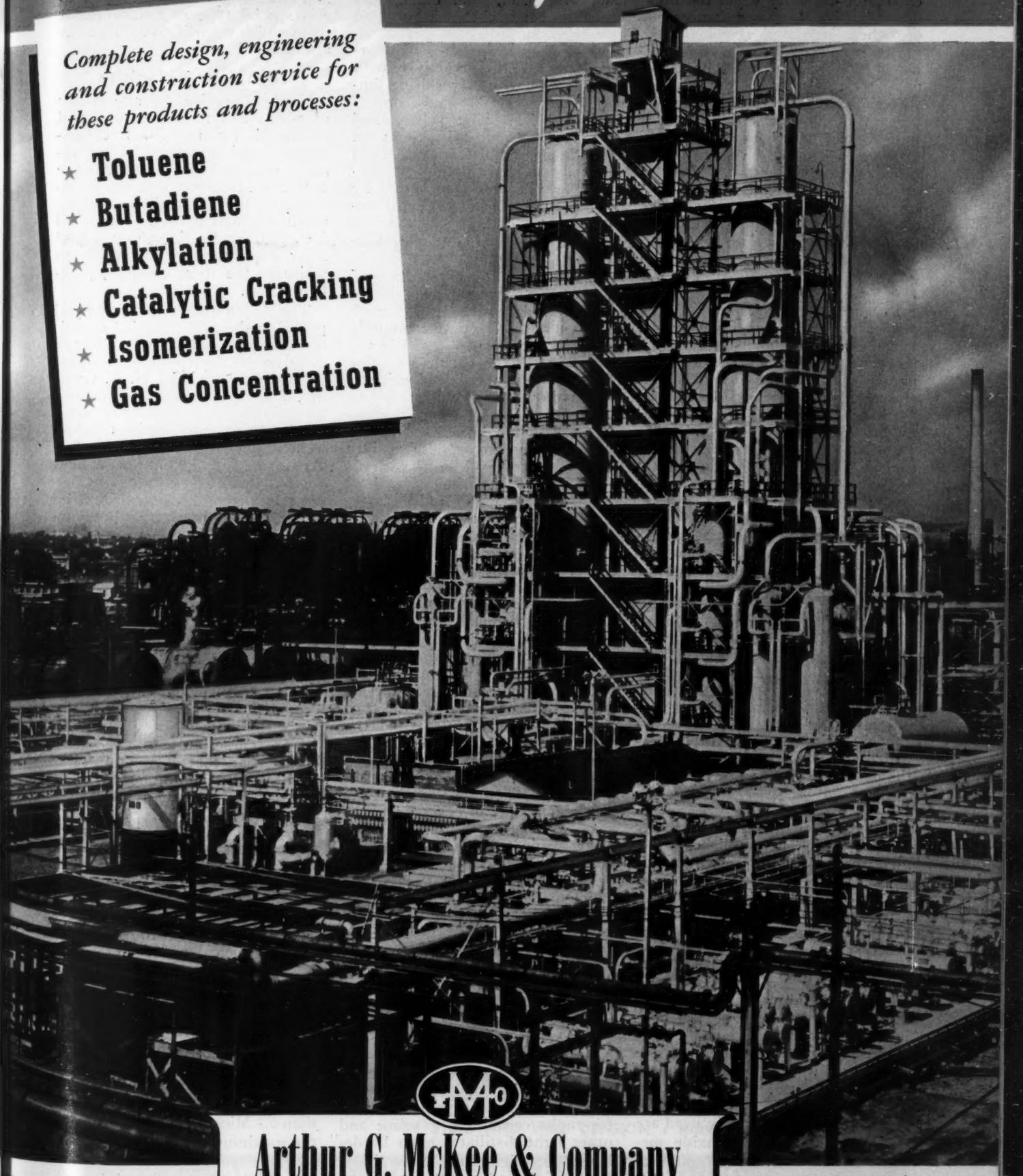

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encounter difficulty when the film is broken by the forming process or when partially removed by weathering. It has been well established that steel painted immediately after fabrication withstands weathering better than steel painted after partial erosion of the mill scale. New tanks are usually allowed to weather sufficiently before painting to permit complete removal of the scale. This may then be accomplished by thorough scraping and wire brushing. Experience has proved that this method of surface preparation is adequate for the application of primers which set relatively slowly.

Recently developed quick drying primers have attracted particular attention to the necessity for thorough and complete surface preparation. These synthetic resin and alkyd type primers possess remarkable drying speed, a desirable quality. They give excellent service when applied to sandblasted or specially prepared steel but have frequently shown unexpected and quick failure when applied to steel prepared in a manner proved adequate for the usual, slower-drying, linseed-oil products. It is our opinion that the failure of these quick-drying primers is the result of their quick-setting properties. Fluidity does not persist for a sufficient time after application to permit complete wetting of the steel, except under highly favorable conditions. The primer bridges over certain irregularities in the steel and ultimately breaks develop in the inadequately bonded paint film, which allow moisture to get under the paint system and destroy it.

The Primer

No paint system has been developed which accomplishes complete impermeability to water and oxygen. When we attempt to increase the impermeability of our primers through replacement of the linseed-oil vehicle with heat-processed synthetic-resin vehicles, we get into difficulties with the attending reduction in fluidity and wetting. Certain pigments of the so-called inhibitive type are utilized in the formulation of steel primers to reinforce and improve impermeability and to add the required inhibitive or corrosion-passifying qualities. The inhibitive pigments most commonly used are red lead, blue lead, zinc oxide, metallic zinc dust, basic chromate of lead, and zinc yellow (a complex zinc potassium chromate). Red lead, blue lead, zinc oxide, and probably basic chromate of lead owe their inhibitive properties to their basic qualities and, in differing degrees, to their reactivity with the vehicle, with a resulting improvement in hardness and impermeability. The zinc yellow and basic chromate of lead possess the passifying chromate radical, while the finely divided metallic zinc pigment imparts protection largely by the favorable electrochemical action of this metal. Highly efficient inhibitive primers are manufactured with these pigments.

The highly basic pigments used in the priming coat are altered quickly and positively by such acidic materials as are commonly found in our atmosphere. We are familiar with the change in color effected when a red lead priming coat is allowed to stand exposed to the weather. Here, the carbon dioxide and sulphur dioxide commonly found in the atmosphere rapidly change the red lead into basic sulphate and basic carbonate of lead — the familiar white lead. It is essential that the red lead act in this highly efficient manner. In doing so the highly corrosive acidic materials that accelerate corrosion are consumed and consequently do not reach the steel surface. However, such rapid chemical change is not conducive to the degree of permanency desired in a paint coating and consequently we must protect the priming coat and finish the job with a different, more stable type of paint — a finishing coat paint.

Finishing Coat

The finishing-coat paint is formulated with pigments that are less reactive. It is designed to resist weathering, promote long wear, retain color, and maintain a uniformly clean appearance. The primer and the finishing coat thus supplement each other, each performing its specific but different task.

Finishing-coat paints are sometimes designed with additional qualities for certain special services. Refinery service, where the concentration of hydrogen sulphide is frequently high, requires the use of lead-free white or light colored paints in order to avoid objectionable darkening and discoloration. The finishing coat paint required for tanks containing gasoline and other light distillates must be desiged for high solar reflectivity. Such special paints reduce the temperature of the tank contents and minimize volatile losses. It is to this special type of finishing-coat paint which we will now direct our attention.

High Solar Reflectivity

For this service the superiority of white has been recorded and published by numerous experimenters and confirmed by the results obtained on large storage tanks. We therefore consider it unnecesary to repeat these data or needlessly add to this established fact. All results, based on actual solar exposure, are favorable to white as the most efficient, practical finish.

The only apparent exception and probably the first recorded experimental work regarding the effect of color on the absorption of a radiant energy were those of H. A. Gardner. This work "Rise in Temperature of Benzine Contained in Small Tanks Painted in Various Colors When Subjected to Rays of Carbon Arc for Period of 15 Minutes" indicates that tinplate records the lowest rise in temperature. Expressed in degrees Fahrenheit, aluminum paint rises 0.7° higher, white paint 2.7° higher and black paint highest by 34.2°. Gardner's data have been quoted in many articles and have been generally accepted as a measure of relative solar heat reflectivity. In so doing we assume that the radiant energy emitted by the carbon arc is the same or at least of similar quality to that received from the sun. This assumption is not correct.

The temperature of the sun is higher than that of any source of radiant energy found on the earth. The highest source of man-made radiant energy, the carbon arc, reaches a maximum temperature approximately one-half that of the sun. Now, as the temperature of the source of radiation increases, the wave length of maximum radiated intensity becomes shorter. This is mathematically expressed by the Wien displacement law:

$$\lambda m T = b$$

λm = wave length of maximum radiated intensity
T = absolute temperature
b = a constant

With this law, assuming the sun's temperature as 6,000° C., we obtain for sunlight a wave length for maximum energy of slightly less than 0.5 Micron. For the carbon arc the maximum energy is found at a wave length close to 1 micron. From these observations it is readily appreciated that Gardner's data

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obtained with the carbon arc are incorrect and misleading. Practical test and experience have proved this. Aluminum shows to advantage where the radiated energy is confined largely in this, the infrared region but is definitely less efficient where the source of radiant energy is solar.

The sun is our chief source of radiant energy. This radiant energy may be either reflected or absorbed. When striking a surface of poor reflectivity it is largely absorbed and converted into heat, which is evidenced by an increase in temperature. When falling upon a surface of high reflectivity the quantity absorbed and converted into heat is comparatively less. This phenomena has been observed by many of us as bare-foot boys when walking on black asphalt pavements as compared with the lighter colored and cooler paving materials. We therefore paint our gasoline and light distillate storage tanks with white or other light colors in order to reflect the greatest proportion of solar energy.

Paints having the highest light reflective values should most effectively reduce tank temperature and show the lowest evaporation loss. Let us, therefore, examine the "reflection values" of several paint colors:

White	*84 percent
Light Gray	53.6 percent
Aluminum	41.9 percent
Black	1.12 percent

The radiated energy of the sun is confined largely to the visible spectrum which covers wave lengths between 0.4 and 0.8 microns. Solar heat absorption should therefore follow closely the values indicated for light reflectance. Practical tests prove that this observation is correct.

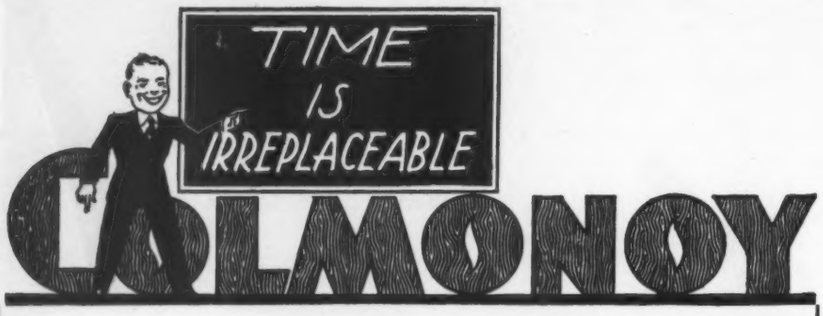
The ideal white paint for high solar reflectivity should include the following qualities:

1. A high degree of brightness or whiteness.
2. The ability to maintain brightness.
3. A high degree of permanence.

The property of brightness or whiteness is imparted only by the pigment. The pigment, titanium dioxide, offers the desirable combination of brightness, opacity, and chemical inertness. The whitest finishes are made with this pigment so naturally its use, as the major pigment component of our white finishing coat, is indicated. The vehicle acts as the binder or adhesive material which holds the pigment together and bonds the paint to the surface. It can add nothing to the original whiteness of the paint. It can, however, by discoloring and yellowing, detract seriously from the paint's reflective quality. The most desirable qualities for this special finish are obtained when the quantity of pigment in the dried paint film is high. We can readily appreciate that where the reverse is true and we have a preponderance of vehicle or binding material we are proportionately decreasing our reflecting component and producing a finish which will soil more rapidly. This is due to the property of all vehicles to collect and hold dust and other foreign materials. We do not, therefore, desire a gloss finish. The most practical finish for this service is one of medium gloss—a semi-gloss or eggshell finish.

The second quality, ability to maintain bightness, is a problem which must be solved by the paint formulator. He must balance pigment and vehicle both in quality and quantity to obtain the most

*Light reflection efficiencies determined by Munsell Color Company, Inc., Baltimore, Md.



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desirable and the fewest undesirable properties. The paint must dry sufficiently fast to avoid serious dirt collection. It must, by slow and controlled chalking, maintain the degree of cleanliness required by the environment. It should accomplish this without serious erosion and attending short life.

It is an established fact that stone, glass, metal, concrete and composition shingles collect dirt and become dingy and, in industrial areas, become actually black in appearance. In other words, all surfaces which are relatively permanent in nature and show little or no surface decomposition, become dirty and unsightly. Paints are no different from other materials in this respect—as their durability is increased at the rate of surface failure retarded, their tendency to collect dirt increases. When paint soils, its reflective quality approaches that of the adherent dirt film which is invariably lower than that of a white finish. Soiling will be quite noticeable on a paint of high reflectance but not easily seen on the darker finishes of poor reflectivity.

The rate of surface renewal required in order to maintain the desired brightness will vary with the environment. In the Pittsburgh area a comparatively free chalking special white paint is required. On the other hand, for the vast majority of localities a slower chalking and consequently more durable white has proved satisfactory. In this type of paint the formulator has utilized the most recently developed and improved alkyd vehicles. This has permitted the manufacturer to produce excellent finishing-coat white paints of high solar reflectivity which combine initial whiteness and satisfactory retention of brightness, with durability.

In vertical tanks, solar heat is absorbed largely through the tank roof. This fact is recognized by the special attention given to insulate the roof and protect this area with the aid of water or a sunshade, etc. Maximum economy is obtained by painting the tank top with the most efficient product—a fume-proof top white.

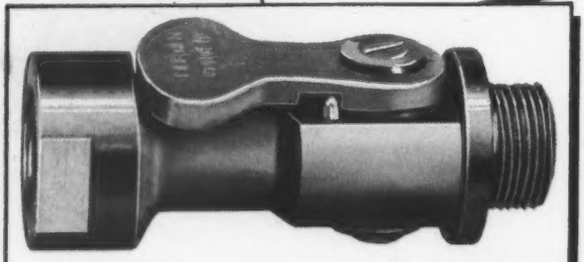
The area of the tank roof is approximately 40 percent of the entire painted tank exterior. It may be repainted, however, with the least expenditure of labor and cost. The shell or sides of vertical tanks may be painted with a more durable, darker, though relatively less efficient finish in regard to solar-heat reflectivity. The intensity of sunlight striking the sides of the tank is comparatively low. With this tank painting program which specifies a white roof with aluminum or gray sides, or in spheroid design a completely white surface, we approach the optimum condition—maximum solar heat reflectivity, minimum evaporation losses, and lowest maintenance cost.

These low-cost items save time, labor and money in tube cleaning

Anything that saves time, labor and materials is good news today. The accessories illustrated may be used with most makes of tube cleaners. Write for details.

Combination drill heads offer savings

This head is an exclusive Roto economy feature. Consists of three separately replaceable parts, made of different materials to suit the type of wear to which each is subjected. Worn parts are renewed at great savings over the cost of ordinary one-piece drills.



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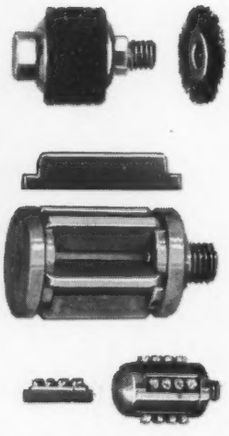
Enables one man to operate the tube cleaner by himself. Saves time too, because it eliminates the necessity of signalling a helper to turn the air on and off between every tube cleaned. Attachable to most makes of cleaners for straight or curved tubes.



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Roto brushes with replaceable sections (top), expanding scraper heads with renewable blades (center), and expanding brushes with replaceable sections (bottom) provide great economies in cleaning small tubular equipment. Roto heads give long, satisfactory service.

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WPRA Schedules One-Day Meeting in St. Louis

The annual meeting of the Western Petroleum Refiners Association will be confined to one day, March 25, in the Jefferson Hotel, St. Louis. This decision followed cancellation of the three-day session, previously made for New Orleans.

One session in the morning and another in the afternoon will complete the program. Wright W. Gary, director of refining, Office of the Petroleum Coordinator, will speak extemporaneously on "The Importance of Refining in Wartime Economy."

The business session will include election of officials and a meeting of the board of directors.

Mid-Year Meeting of API Is Called Off

Because of the demands military activity is making on personnel of the petroleum industry, the mid-year meeting of the American Petroleum Institute has been cancelled. It had been scheduled for May 25, 26, 27 and 28 in Oklahoma City. In announcing the decision W. R. Boyd, Jr., president, said:

"This action has been taken by the institute's executive committee upon my recommendation because so many of the members of the institute, and especially of its working committees, who normally attend mid-year meetings, are actively engaged in war work."

SAE Establishes West Coast Branch

The Society of Automotive Engineers has established a branch office in Los Angeles to meet the increasing needs of membership in the four Pacific Coast states. E. F. Lowe, assistant general manager, has taken charge of the district with offices at 530 West Sixth Street.

The establishment of the new office, it was announced by John A. C. Warner, SAE general manager, makes the services of the society more available to members on the Pacific Coast.

Members of the society in this area, Warner stated, are engaged in all phases of automotive engineering, including aircraft and aircraft engines, passenger cars, trucks and buses, parts and accessories, fleet operation, and fuels and lubricants. Much of their work is a direct part of the war program, and many members are serving on important SAE committees which are cooperating with the government in coordinating automotive engineering activity directed toward expediting production and transportation of war products.

Committee Named for Property Protection

One of the first moves of the Petroleum Industry War Council was designation of a committee to formulate plans for the protection of all types of petroleum facilities. It will supplement the national and regional committees, named 14 months ago to supervise protection of oil storage by the American Petroleum Institute.

The committee will have headquarters in New York, where its work will be supervised by David V. Stroop, executive secretary, assisted by Harry N. Blakeslee, and will develop a comprehensive organization and program designed to centralize as well as to facilitate and expedite the industry's cooperation with the Army and Navy and other national agencies concerned with the war-time protection of petroleum industry facilities.

Chairman of the committee is W. S. Farish, president of Standard Oil Company (New Jersey), other members being Frank Butram, Independent Petroleum Association; Henry M. Dawes, The Pure Oil Company; W. H. Ferguson, Continental Oil Company; George A. Hill, Jr., Houston Oil Company of Texas; J. C. Hunter, Mid-Continent Oil and Gas Association; N. C. McGowen, United Gas Pipeline Company; W. S. S. Rodgers, The Texas Company; N. H. Weber, National Petroleum Association; H. D. Collier, Standard Oil Company of California; J. Frank Drake, Gulf Oil Corporation; C. L. Henderson, Vickers Petroleum Company; Dana Hogan, Hogan Petroleum Company; B. L. Majewski, Deep Rock Oil Corporation; J. Howard Pew, Sun Oil Company; W. G. Skelly, Skelly Oil Company, and R. E. Wilson, Pan-American Petroleum and Transport Company.

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CONVENTIONS

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23–25	American Society of Mechanical Engineers, Spring Meeting, Houston.
25	Western Petroleum Refiners Association, Jefferson Hotel, St. Louis.
APRIL	
15–17	American Institute of Mining and Metallurgical Engineers, Cincinnati.
16–17	National Petroleum Association, Semi-Annual Meeting, Hotel Cleveland, Cleveland.
20–24	American Chemical Society, Memphis, Tennessee.
21–23	Southwestern Gas Measurement Short Course, University of Oklahoma, Norman.
22–24	Petroleum Industry Electrical Association, Washington-Youree Hotel, Shreveport.
MAY	
11–13	American Institute of Chemical Engineers, Boston.
13–15	Natural Gasoline Association of America, Mayo Hotel, Tulsa.
JUNE	
8–11	American Society of Mechanical Engineers, Semi-Annual Meeting, Cleveland.
22–26	American Society for Testing Materials, Chalfonte-Haddon Hall, Atlantic City.
OCT.	
12–14	American Society of Mechanical Engineers, Fall Meeting, Rochester, N. Y.
25–29	National Lubricating Grease Institute, New Orleans.

Council Given Program For War Operations

An approach by which the petroleum industry can shape its methods to meet the demands of war was laid before the Petroleum Industry War Council by Dr. Robert E. Wilson, chairman of the committee on economics, at its March meeting. The report recommended three broad changes for wartime vs. peacetime operations:

Conservation of materials, manpower and transportation.

Safeguarding against inflationary prices.

Definite relaxation and revision of the anti-trust laws.

At the same time, he said, there are nine problems looming most importantly among the questions with which the committee and its subordinate groups should deal, defining them as:

1. Prepare an estimate of military, industrial and civilian requirements for petroleum products for 1942 and 1943, the schedules to constitute the fundamental basis for many other studies.

2. Tabulate the existing and potential sources of supply by regions and with relationship to available crude supplies and by-products needed for military use.

3. Prepare for the council a supply program to meet the estimated requirements, drawing such requirements from those sources which would afford the greatest efficiency in the use of materials, man-power, transportation and time, without adversely affecting the supplies of by-products needed for the war.

4. Prepare an analysis of the Western Hemisphere transportation situation with reference to the existing tanker shortage, studying possible remedial measures and the most efficient methods of using new and supplementary facilities.

5. Analyze estimates of civilian and industrial requirements from the point of view of the necessities of consumption, realizing that oil products are essential to millions in the functioning of the war effort.

6. Analyze the effect of major new projects with the view of comparing with possible alternatives.

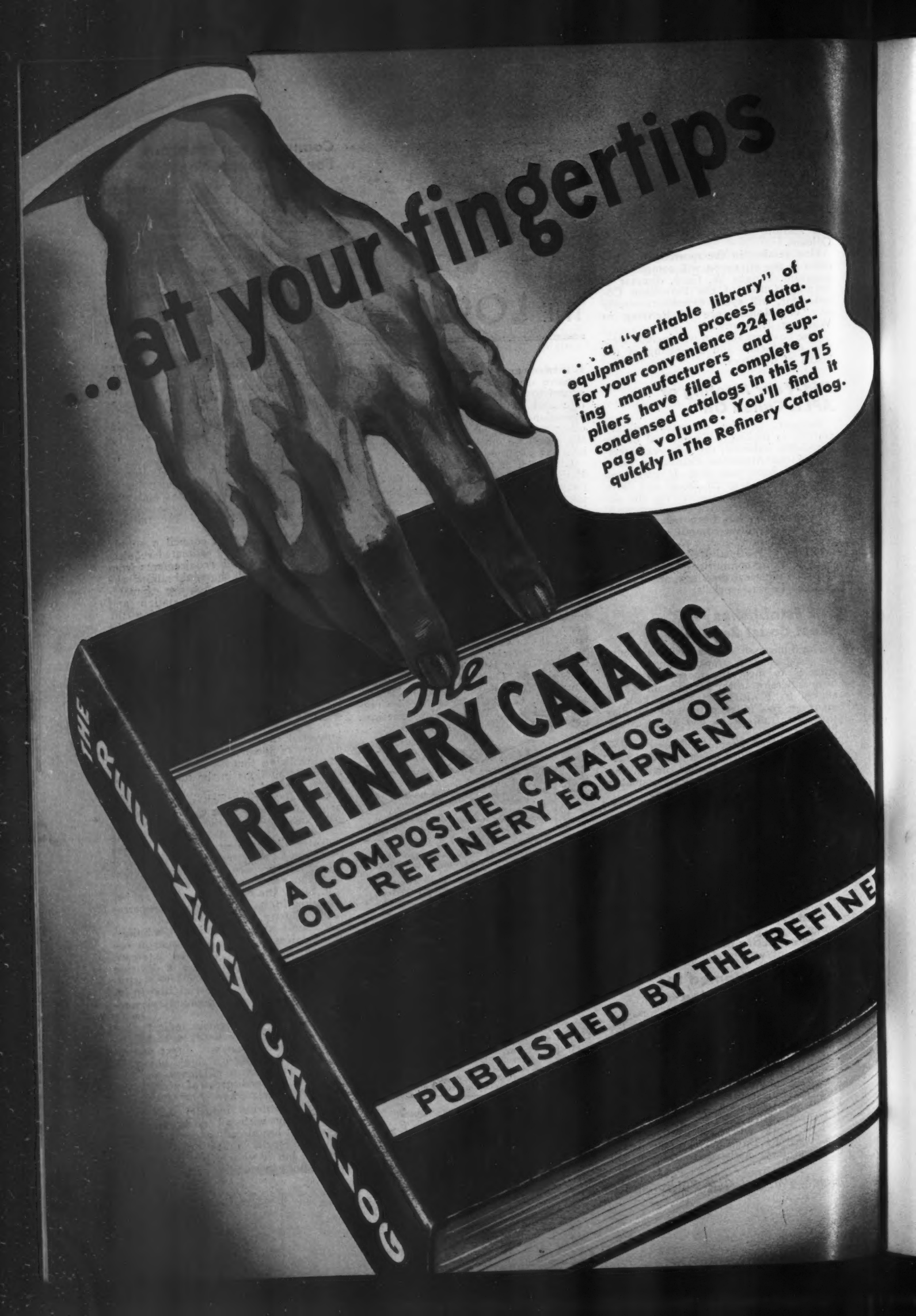
7. Study future dislocations of the industry likely to result from changes in demand as between products and regions, and prepare schedules of action in advance to meet these conditions.

8. Study the economics of the rubber situation in its effect upon the petroleum industry.

9. Study the economics of administered prices in their bearing upon operating results and national interests, and explore the possibilities of devising methods for freezing price levels without creating undesirable rigidities in inter-product and inter-regional price relationships.

"Events of recent weeks indicate that this country vitally needs a technique of management that will direct our industrial resources to a single objective, with the maximum efficiency and the minimum expenditures of time," the committee declared.

"The petroleum industry has cooperated fully with all government requests and has already accomplished remarkable results in meeting all demands to date, but in view of the tremendous dislocations in supplies of materials and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transportation facilities and demands for products which are facing us, the industry must take more initiative and be prepared for greater sacrifices in order to adapt its operations fully to war requirements."

The major problem, the report maintained, is to develop methods of saving materials, man-power and transportation by avoiding such things as unnecessary construction or unessential cross-hauling and other duplication, but at the same time preserving the advantages of the individual initiative of thousands of organizations.

Pledging the industry "to subordinate everything to its war obligations," the committee set the standard of war time economy as "not dollars but materials, man-power, transportation and time."

"The application of these standards means that existing equipment of the industry must be utilized to the fullest extent," it explained. "New facilities should be constructed only as a last resort. Additions to marketing facilities can be countenanced only where directly necessary to the war effort. Refinery installations should be permitted only if possible combinations of existing facilities are inadequate or unduly inefficient. The production branch of the industry must undertake to devise equitable methods which will permit sharp curtailment of its use of steel.

"The guiding principle of wartime economics may be very tersely expressed. This principle is that existing facilities should be so utilized as to meet essential needs with the greatest efficiency in terms of physical standards; man-power, materials, transportation and time. As corollaries to the general principle of maximum utilization of existing facilities, there are three aspects deserving particular mention, as follows:

"1. Construction of new facilities so far as possible should be deferred until the post-war period, and where such construction is necessary it should be so located and planned as to minimize the use of materials that are scarce.

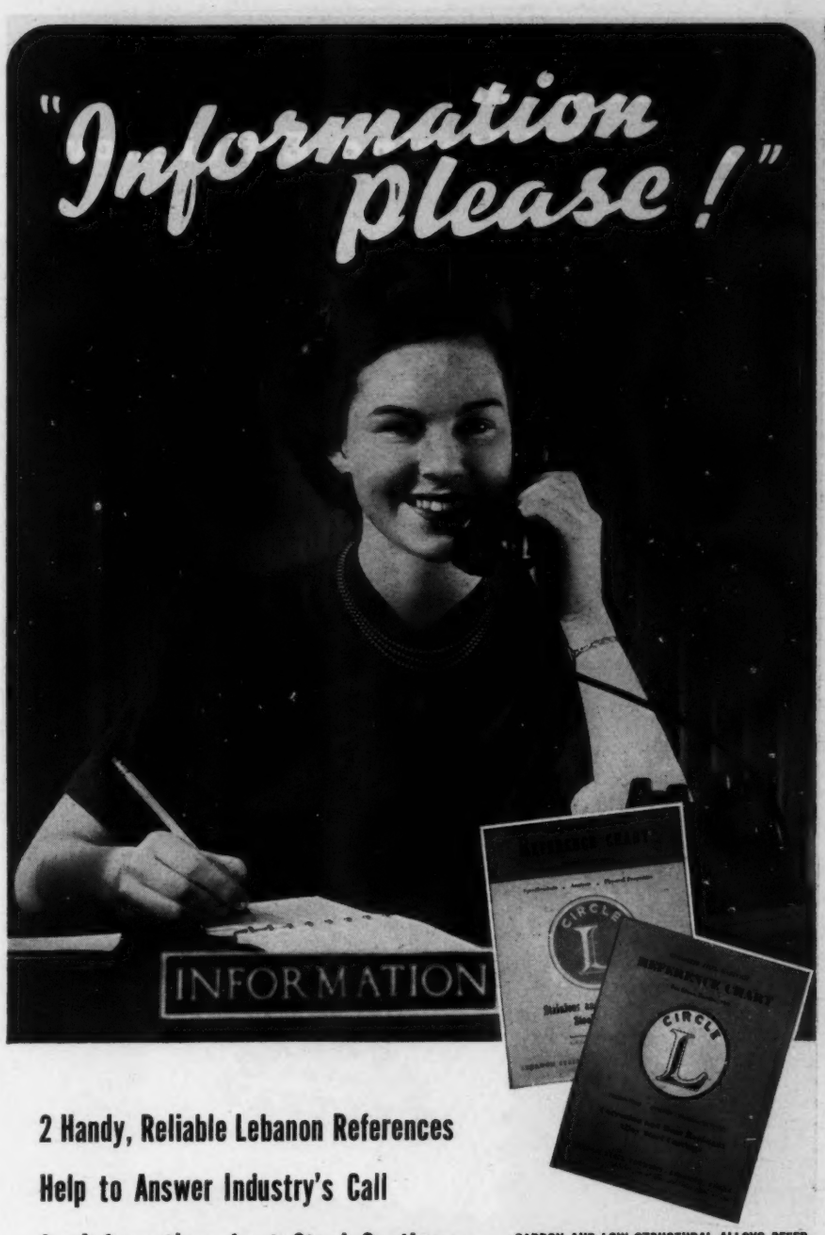
"2. Where supplies are short, non-essential demands should be modified, shifted, or curtailed.

"3. Where transportation is the bottleneck, available facilities must be used in a way to give maximum efficiency."

The impact of such a program on the industry naturally will not fall equally on all interests concerned, it was admitted, and consideration should be given to ways and means of sharing any burdens imposed, so that the relative situation of competitors is not unduly disturbed by the cooperative programs which are necessary in the interests of efficiency. Pooling of stocks or facilities and equitable sharing of added costs were cited as examples of ways in which this can be done.

With respect to prices, the committee held that "the economic necessity for emergency price regulation by the government in order to avoid inflation should be recognized and accepted, but at the same time ingenuity should be exercised to devise non-inflationary incentives where necessary." But, it warned, "methods must also be devised to keep the components of the petroleum price structure flexible to meet promptly the changing needs for products at different times and in different regions, without disturbing the general price level."

At the same time, the committee held



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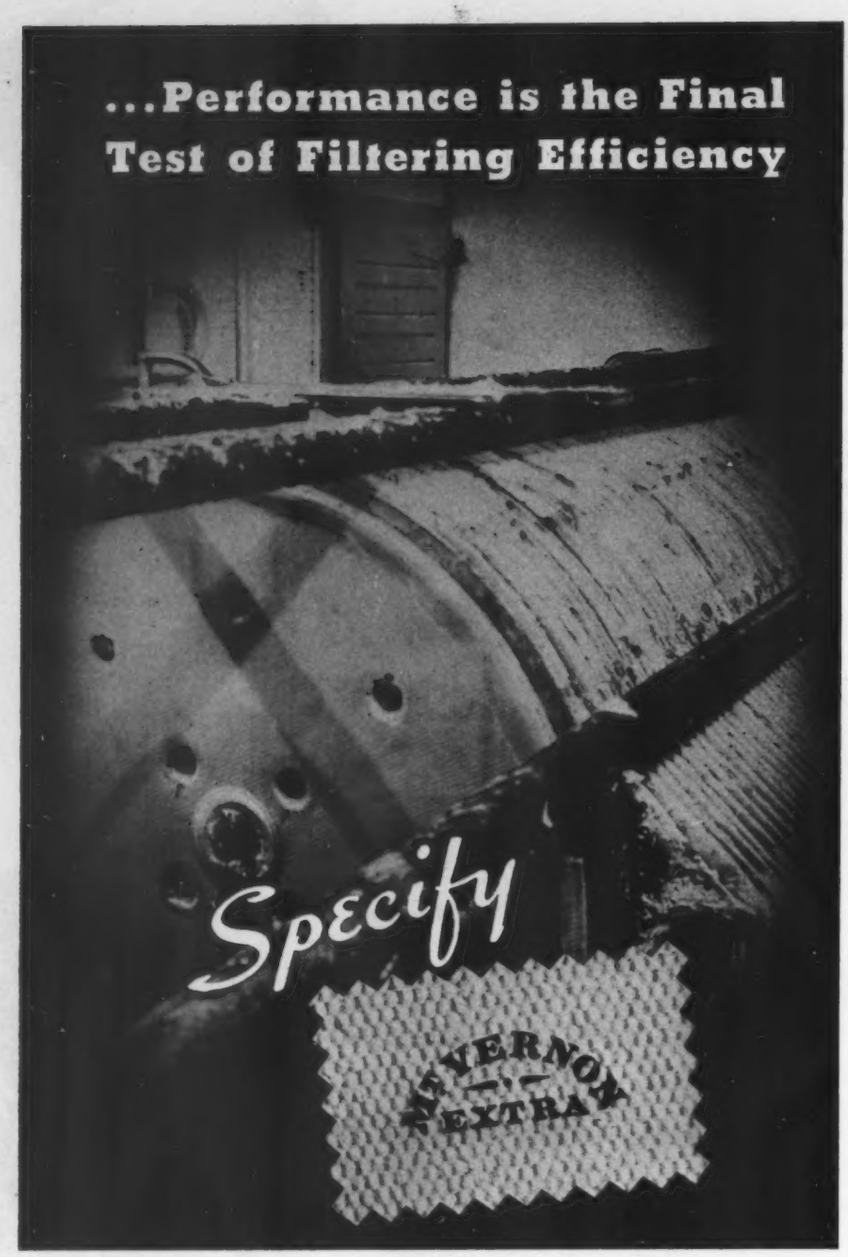

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that if the recommendations to secure efficient coordination of industry activities to meet war needs are to be effective, "some more definite and positive relaxation of the anti-trust laws appears necessary.

"The present practice of obtaining clearance letters from the Attorney General," it said, "appears both cumbersome and inadequate to facilitate what needs to be done to meet war needs."

"The importance of visualizing the full scope of the war and the part that the petroleum industry must play therein cannot be over-emphasized," Wilson declared. "If the proper course of action is followed then the industry may emerge from this crisis economically stronger, better balanced and better equipped to meet post-war obligations. On the other hand, the principles of pre-war economics must not be permitted to guide its conduct under conditions where they are no longer appropriate, even if such programs are accorded government acquiescense for the time being."

Name Changed to Industry War Council

The name of the Petroleum Industry Council for National Defense has been changed to Petroleum Industry War Council. The change was made by Petroleum Coordinator Harold L. Ickes, who explained:

"The change in the designation of the representative group of 72 industry leaders gives formal recognition to the fact that the prime function of the council is that of aiding the coordinator in securing all-out industry participation in the war effort.

"In effect, the group has been serving as a war council from its very inception. Established in November, it held its first meeting on December 8, 1941, the day after the Japanese attack on Pearl Harbor."

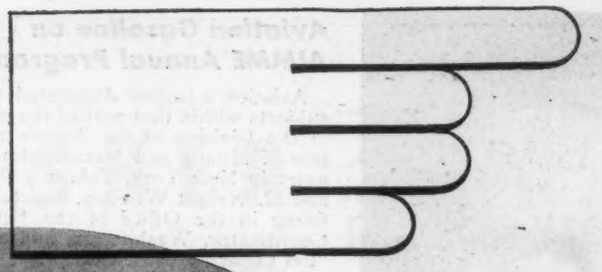
Scheumann Is Cities Service Superintendent

W. W. Scheumann has been appointed general superintendent of Refining for Cities Service Oil Company. Since 1937 he has been chief chemist for the refining division. The promotion which became effective March 1 followed the resignation several months previous of L. D. Mann, who is now in governmental work. He will have charge of operations of the concern's three plants at Okmulgee, Ponca City and East Chicago.

Scheumann was born in Lafayette, Indiana, and is a graduate of Purdue University in chemical engineering. After doing research work with The Aluminum Company of America, he joined the Cities Service organization as a chemist at the East Braintree plant in 1924. Two years later he became chief chemist at this plant.

In 1931 he came to the Okmulgee plant of Empire Oil & Refining Company. In 1937 he was made chief chemist for the refining division, which had headquarters in Tulsa until it was transferred to Bartlesville two years ago.

He is a member of the American Chemical Society, the American Society for Testing Materials, the Society of Automotive Engineers and the American Petroleum Institute. He has been active in the technical programs of the



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Western Petroleum Refiners Association and two years ago prepared the paper, "Octane Numbers—The Refiner's Will o' the Wisp," which was presented before the annual convention of that organization and later widely printed within the industry. He is a member of District 2 sub-committee on aviation gasoline.

Aviation Gasoline on AIMME Annual Program

Aviation gasoline dominated refining subjects within that part of the program of the Division of the American Institute of Mining and Metallurgical Engineers in New York, February 9, 10, 11 and 12. Wright W. Gary, director of refining in the Office of the Petroleum Coordinator, Washington, had a paper, "100 Octane Aviation Gasoline, Present and Future;" while J. F. Thornton and W. C. Deckerman, Jr., The Lummus Company, New York, presented a paper, "Petroleum Refining Methods Available for Wartime Demands."

Eugene A. McAuliffe, Union Pacific Coal Company, Omaha, was elected president of the Institute, succeeding John R. Suman, vice president of Humble Oil & Refining Company, Houston.

Vice presidents and directors of the institute elected this year are: Chester A. Fulton, president Southern Phosphate Corporation, Baltimore, and L. E. Young, consulting mining engineer, Pittsburgh. Directors are: Charles Camsell, Department of Mines and Resources, Ottawa, Canada; C. A. Garner, vice president Jeddo - Highland Coal Company, Jeddo, Pa.; William B. Heroy, president Pilgrim Exploration Company, Houston; Wilber Judson, vice president Texas Gulf Sulphur Company; L. F. Reinartz, manager American Rolling Mill Company, Middletown, Ohio, and Francis A. Thomson, president Montana School of Mines, Butte.

The following officers were elected by the Petroleum Division: Chairman, Harry P. Stolz, Stanley & Stolz, consulting engineers, Los Angeles, Associate chairmen (3) W. S. Morris, East Texas Engineering Association, Kilgore; Veleair C. Smith, consulting engineer and geologist, Charleston, West Virginia, and Charles A. Warner, engineer and geologist, Houston Oil Company, Houston. Secretary - treasurer, Harold Vance, petroleum engineering department, Texas A. & M. College. Harry P. Stolz was named chairman of the executive committee, the committee including C. J. Boberly, president Kobe, Inc., Huntington Park California; R. B. Kelly, division manager The Pure Oil Company, Olney, Illinois; F. B. Plummer, University of Texas; C. E. Reistle, chief petroleum engineer, Humble Oil & Refining Company, Houston, and E. A. Stephenson, University of Kansas, Lawrence, Kansas.

HARRY P. STOLZ

Following are the new chairmen of standing committees of the Petroleum Division: Production Engineering, C. H. Keplinger, Shell Oil Company, Tulsa; Associate Chairman, Production Engineering, E. K. Parks, consulting geologist and engineer, Los Angeles; Production, B. B. Zavoico, Chase National Bank, New York; Associate Chairman of Production, M. T. Halbouty, consulting geologist and engineer, Houston; Associate Chairman of Production, Winthrop P. Haynes, geologist Standard Oil Company (New Jersey); Engineering Research, P. E. Fitzgerald, geologist Dowell, Inc., Tulsa; Economics, Norman D. Fitzgerald, Chase National Bank, New York; Refinery Engineering, Walter Miller, vice president Continental Oil Company, Ponca City; Membership, Paul Weaver, geologist Gulf Oil Corporation, Houston; Papers and Program, Stuart Buckley, Production Research Department Humble Oil & Refining Company, Houston; Associate Papers and Program, E. G. Trostel, petroleum engineer Union Oil Company, Santa Fe Springs, California.

Relative to refining, Gary discussed the present status and future course of 100-octane aviation gasoline production and considered that after the war, demand would be maintained for this

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specialized product. A paper by J. F. Thornton and W. C. Dickerman, Jr., The Lummus Company, discussed modern refining processes with particular reference to production of ingredients of high-octane gasoline and selection of specific processes for particular situations.

The Petroleum Division's new chairman, Harry P. Stolz, could not be present to assume office during the division's annual dinner held February 12 at the Roosevelt Hotel. Stolz is in the Naval Service in California. In behalf of Stolz, C. J. Coberly took over the chairmanship from the outgoing chairman, Eugene A. Stephenson.

The Petroleum Division dinner was decidedly a light-hearted affair this year. E. J. Kennedy, assistant to the secretary of the institute in New York, said he had attended many petroleum dinners but had never seen such good will and wit as flowed during the dinner last week.

Among those at the speakers table in addition to Coberly and Stephenson, were John R. Suman, outgoing president, John M. Lovejoy, J. B. Umpleby, E. DeGolyer and James Terry Duce.

The after-dinner speaker was Ray L. Dudley, president of The Gulf Publishing Company, whose subject was "Wanted—Petroleum Leadership."

An abstract of the paper by Wright W. Gary follows.

Lessons of the war have already taught that ultimate victory will probably go to the side which has superiority in numbers of planes, plane design and fuel, and without superior fuel the other superiorities are hard to obtain. The oil industry faces mass production of superior fuel. Within the past six months, projected demand for aviation gasoline has doubled, trebled, quadrupled and is still rising.

The basic constituents of 100-octane fuel are generally considered to be: a base gasoline, high-octane blending agent, light blending agent and tetraethyl lead. With the exception of lead, some of the foregoing materials vary in quality, so that different percentages of each constituent are needed to make a 100-octane fuel. A base gasoline is generally a high-octane material of suitable boiling range distilled from crude or natural gasoline. Supplies of base gasoline are limited, but can be augmented by such processes as catalytic cracking, hydroforming, isomerization and other new processes which require costly investments and specialized plant facilities. The term "high-octane blending agent" generally means a material synthesized from selected refinery gases produced as by-products. The supply of blending agents is limited. A "light blending agent" is the low-boiling material needed for proper volatility of the finished aviation fuel. So far it has come largely from selected fractionation of oil field gases and special distillation of ordinary gasolines. The supply of light blending agents is limited but can be increased by such processes as catalytic cracking, isomerization, polymerization and alkylation.

Aviation gasoline quality has a vital bearing on air engine performance. Some of the advantages of 100-octane fuel are: about 26 percent more power at take-off than is possible with 91-octane, an increase of several thousand feet in flying ceiling, and reduction of motor weight

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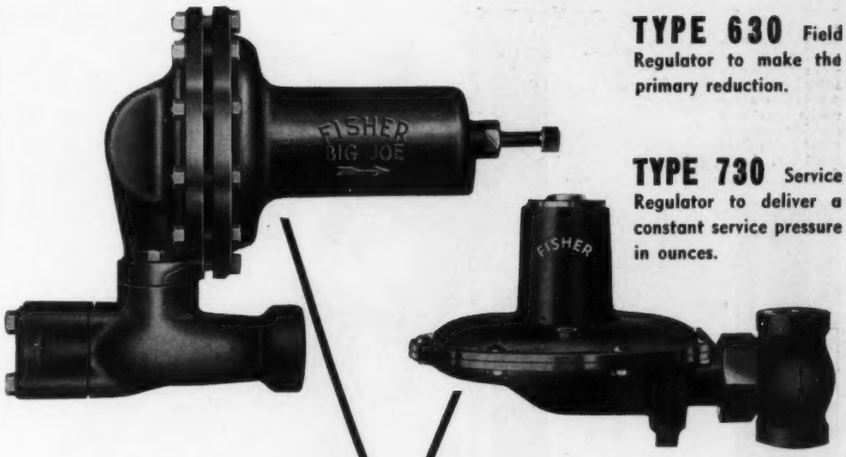

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by as much as 40 percent as compared to operation with 91-octane fuel.

We are considering fuels of above 100-octane today. They can be made in any 100-octane plant, but volume of production is proportionately reduced. Supply vs demand will largely dictate qualities better than 100-octane, but the refining industry can provide the air forces with real air supremacy.

Economics of aviation gasoline manufacture vary considerably because of two main factors: size of plant and kind of process used. A large volume in any given plant demands a substantial crude throughput. Effort has been made to increase production of aviation gasoline per barrel of crude so that small plants can make this fuel. Studies have involved collection of refinery gases, consolidation of polymer gasolines from small refiners in a central plant, and delivery of such charge stocks as gas oil and reduced crude to a central catalytic cracker and alkylation plant. Economic studies have indicated that the central catalytic cracking unit has several advantages with respect to investment per barrel of 100-octane, operation costs and greater incremental output per barrel of crude. Such a plant can produce in a single unit over 10,000 barrels daily of aviation fuel, thus cutting need of construction materials.

As to future disposition of 100-octane fuel after the war, it is a personal view that this fuel will be consumed in the following ways: (1) In the conservation of crude, automobiles will be built to use this fuel. Such cars are being designed. (2) The public will fly more. (3) Planes will be used after the war for world-wide passenger and freight service. (4) For various reasons, nearly all 100-octane production will be centered in this country after the war, and the world will buy it.

The future of 100-octane fuel is not a dark one.

The paper on refining methods by J. F. Thornton and W. C. Dickerman, Jr., dealt largely with means of providing an adequate supply of aviation motor fuel with the following summary:

The industry has found that the most satisfactory 100-octane aviation fuel is a blend of 15 to 20 percent of isopentane, selected base stock and enough high-grade, high-octane blending agent, such as alkylate, to carry the blend to 100-octane with ethyl fluid. Isopentane ordinarily is fractionated from natural or straight-run gasoline, but is present in gasoline from some catalytic cracking units and thermally cracked gasoline. The overall supply of isopentane is adequate.

The base stock used in aviation blends must be of good octane number and high lead response. The material should preferably come from straight-run gasoline fractions and special catalytic gasolines because of their high stability and low gum formation. The supply of base stock must be augmented by such processes as close fractionation of isoparaffins out of gasolines containing these, by catalytic isomerization of naphtha and desulphurization of high-sulphur base stocks to improve their lead response. Such processes are in commercial operation.

Alkylation is the most widely used process for making high-octane blending agents, although selective polymerization of butylenes and subsequent hydrogenation is also available. Among the olefins which will alkylate, the butylenes are preferred. In general butylene and isobutane give the highest octane number product and use the least amount of catalyst. The increased demand for alkylate requires the revamping of existing gasoline plants to give higher recoveries of isobutane and supplementation of this supply with isobutane from isomerization units, thermal cracking units and catalytic cracking units. Butylene production will be raised by various cracking operations and catalytic dehydrogenation. The rising use of butanes and butylene in making alkylate and synthetic rubber will reduce the availability of these materials as bottled gas and their use in motor fuel. Propane may have to be used in many cases to meet motor-fuel vapor-pressure requirements.

The discussion of consumption for the past year, "World Consumption of Petroleum and Its Substitutes in 1941," was prepared by V. R. Garfias, R. B. Whetsel and J. W. Ristori, Cities Service Oil Company. The following abstract was made.

Figures of World consumption of petroleum and its substitutes in 1941, which obviously are largely conjectural, are estimated at 2,066,653,000 barrels. It is 48,689,000 barrels more than the previous year and is an all-time high. This figure except for the United States, does not include consumption for military purposes. Consumption in the United States also reached an all-time high during 1941, totaling 1,492,000,000 barrels, or 158,230,000 barrels more than the previous peak year of 1940. On the other hand, it is estimated that civil con-

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sumption in countries outside of the United States decreased 109,541,000 barrels as compared with the previous year.

Demand for military purposes and/or additions to stocks in countries outside the United States is estimated at 304,507,000 barrels during 1941 compared to 209,635,000 barrels in 1940. This increase was due largely to blitzkrieg warfare on several fronts especially Russia which resulted in large expenditures of petroleum by both sides due to the immense area covered by the fighting forces, the long supply lines necessary and the intensity of the fighting.

It is interesting to note in this connection that Axis-controlled countries, excluding Japan, had an estimated production of approximately 89,000,000 barrels of petroleum and its substitutes in 1941. The peacetime consumption of these countries in 1938 for example, was about 183,000,000 barrels. It is believed that the minimum to which civil consumption could possibly be reduced in war time is 20 percent of peacetime, which would call for a minimum consumption in these countries in 1941 for civil purposes of 37,000,000 barrels. This would leave a balance of only 52,000,000 barrels or 142,000 barrels daily available for military purposes in 1941 and any additional supplies must come from storage.

Regarding Japan if we take 20 percent of its 1938 civil demand of petroleum and its substitutes, which consumption was already then substantially reduced because of the war with China, we would arrive only at 5,000,000 barrels. The 1941 production of petroleum and substitutes is estimated at 8,200,000 barrels, leaving 3,200,000 barrels, or 8800 barrels daily for military purposes, indicating the almost certainty that Japan must either capture new sources of supply or continue to make storage withdrawals.

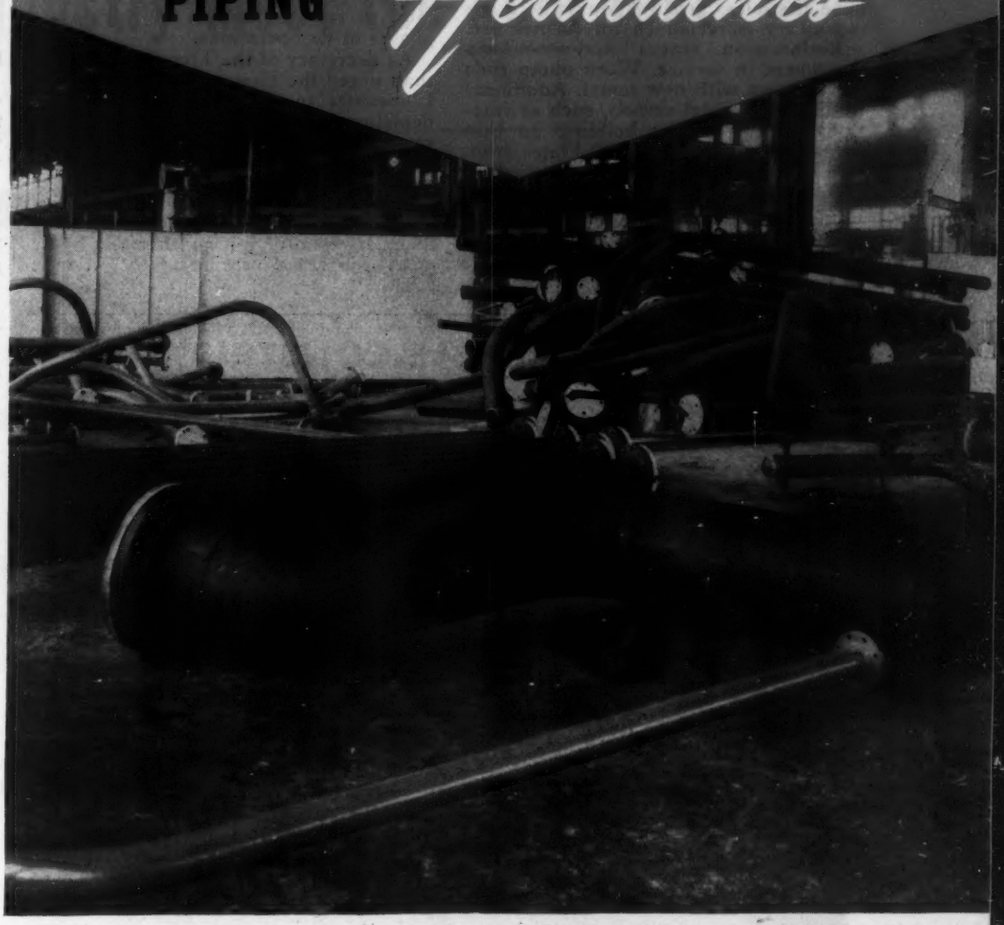
Socony-Vacuum Pushes Scrap Reclamation

"We have always been 'Scotchy' about utilizing and scrapping old materials in our Socony-Vacuum Oil Company plants," said a company official in the East last week, "but we're Scotchier than ever under present conditions." This attitude underlies the intensive scrap reclamation program under way in the company's East River refinery at Brooklyn, New York. Similar programs exist in the company's other East Coast plants including those at Buffalo, and Olean, New York, Paulsboro, New Jersey, East Providence, Rhode Island, and Franklin, Pennsylvania.

In the plant at Brooklyn, for example, the refinery personnel, particularly maintenance men, machinists and pipe fitters, are thoroughly conscious of the necessity to save old materials either for reuse or for conversion into scrap. Scrap piles are kept down. Waste receptacles are stationed about the plant for the collection of small metal pieces of iron and steel. Non-ferrous scrap is separately collected.

Equipment taken out of use is put into two principal categories. One group, consisting of non-machinery items such as piping, valves, pipe hangers, gears, condensers, stanchions, stills and tanks, is junked unless the materials can be reused. The other group consists of ma-

THREE INDUSTRIES SUB-CONTRACT PIPING "Headaches"



UPPER LEFT, process piping for oil refinery CENTER, mine shaft piping RIGHT, important links of a steam power installation

THREE different industries – a power plant, an oil refinery and a mining operation – escaped the "headaches" of new piping installation when they *sub-contracted* the prefabrication to Grinnell!

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WHENEVER PIPING IS INVOLVED

chinery, such as compressors, blower engines, motors, pipe threaders and lathes. When these machines can no longer be used they are sold to second-hand equipment dealers, many of whom have first-class repair shops where the machinery is reclaimed for further use.

Reclamation serves first to keep equipment in service. Worn pump rods are built up with new metal. Additional life is given metal vessels, such as fractionating towers, by building up thin spots caused by corrosion. Plates from two old tanks were recently used in building a new tank. Piping and cracking tubes are often used to make stanchions. The useful life of some cracking tubes is extended by putting new ends on them.

☆ WASHINGTON ROUNDUP ☆

Recent developments in Washington indicate that the oil industry is beginning to feel the impact of war in all phases of its operations.

As Secretary of the Treasury Morgenthau urged the House Ways and Means Committee to eliminate the percentage depletion allowance, double the tax on gasoline and make even further increases in the levies on transportation and lubricating oil, in addition to higher income and corporation taxes, the industry was urging OPA Administrator Henderson to give it another and badly needed increase in prices in the Atlantic area.

Refining along with production felt the pinch of transportation deficiencies, which led OPC to order a reduction in the March allowables for four of the five southwestern states in District 3.

At the same time, a committe of the war industry war council reported that the industry will have to revamp its whole structure to meet the needs of war.

The threat of rationing of gasoline drew closer as OPA revealed that motor-fuel stocks on the Eastern seaboard are beginning to decline because of the diversion of facilities from clean service to the movement of oils.

Determined not to let the East suffer alone, OPC called on the industry nationally to develop methods for the equalization of transportation facilities. Rationing, if adopted, will probably be applied nationally, but the oil coordinator still is anxious to avoid that step, which would lead to development of seriously dangerous stocks of gasoline for which there would be no market whatever.

But from a different angle—that of conserving rubber—Price Administrator Henderson told a Senate committee during the week that rationing of gasoline should be instituted.

A three-way approach to the problem of the East Coast shortage was developed during the week by the industry war council and the coordinator.

As seen by the council and OPC, the progressive steps to meet the situation are:

Reimposition, but on a national scale, of the curfew on filling stations, which Ickes on March 5 said he would act on immediately, with a possible closing of stations on Sunday,

Restrictions on deliveries to stations, and, if unavoidable,

Rationing.

Still seeking to avoid the final step, Ickes said all other methods of keeping the country's automobiles going would be thoroughly explored. There is a difference of opinion in the industry as to the need for rationing, he disclosed, and there is also a difference of opinion on the question of Sunday closing.

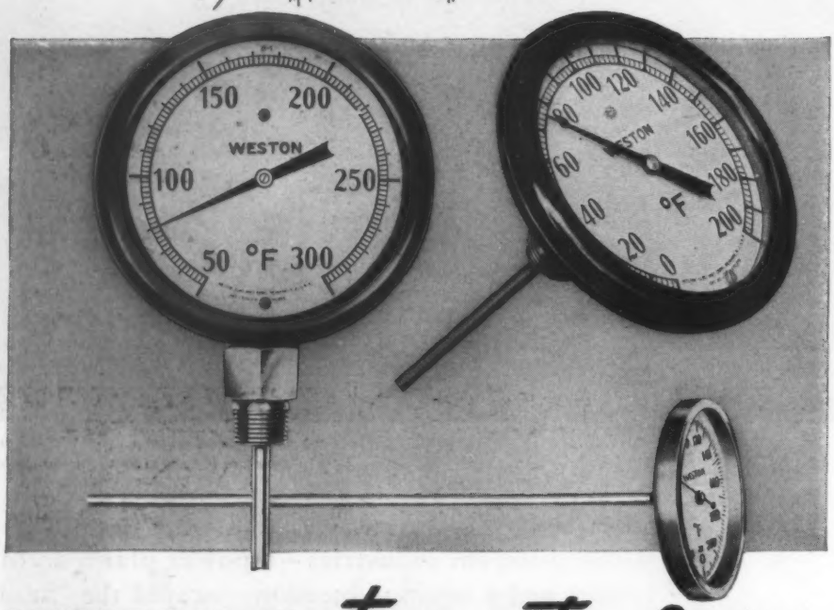
The coordinator emphasized that if rationing is adopted, it will be "equitably distributed" throughout the country—in other words, will be national. It will not only set the amount of gasoline which an automobilist may secure, but it will also set up priorities so that essential services may be continued.

Later Ickes explained that any plan recommended would take cognizance of local conditions of supply, particularly where refinery operations result in readily available stocks.

"If it is necessary to make recommendations to Mr. Henderson for rationing," he said, "the OPC naturally will consider the question of availability of petroleum products. It will take into account the fact that in refinery areas large stocks of petroleum products may accumulate owing to the unavailability of transportation. Any plan for rationing which we might recommend will recognize this fact.

"It will take some time to print ration cards," he said, in discussing the future possibilities. "Originally we were going on the theory that if there had to be

RUGGED ALL-METAL CONSTRUCTION
CUTS BREAKAGE COSTS!



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Today it takes real ruggedness to withstand the mechanical abuse around the active plant. That's one of the reasons why more and more plants are installing WESTON Temperature Gauges. Their all-metal construction eliminates much of the common breakage, thus safeguarding against frequent interruptions and replacement costs. In addition to ruggedness; however, WESTON all-metal Temperature Gauges also provide the advantages of *pointer reading*. Their large, dial-type scales can be read accurately from a distance, and they can be mounted at any angle most convenient for easy reading. Available in types, sizes, stem lengths and ranges for most industrial applications. Accuracy guaranteed within 1% for the industrial types . . . ½ of 1% for the laboratory type. The coupon below will bring complete information.

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Helping Industry Meet the Acid Test

1. ACIDS HOLD A FRONT LINE POST in America's production battle. In munitions factory, metal plant, oil refinery and textile mill . . . acid tanks, pipe lines and heating coils must resist the attack of industrial acids . . . keep them on the job without shut-downs for repairs . . .

2. THAT'S WHY TELLURIUM LEAD is so well-suited for such equipment. This new alloy laughs in the face of hot sulphuric and other acids. A high-temperature lead, it has great resistance to acid corrosion — even at temperatures approaching its melting point. Thus it helps equipment stand up longer — helps keep it on a 24-hour shift . . .

3. EQUALLY IMPORTANT, TELLURIUM LEAD *strengthens under stress* — actually "work-hardens". Tough to start with, it gets *tougher* when hammered, rolled, bent or stretched. Thus joints and turnover points are less subject to cracking . . . buckling and creeping are minimized . . . and resistance is increased to vibration and to fracture from repeated temperature changes . . .

4. TELLURIUM LEAD COMBINES these important new advantages with the well-known properties of St. Joe chemical lead because it is a special alloy of this time-tested metal and Tellurium. Fabricated in sheets, pipes and coils, its use in vital industrial spots is helping Liberty's Arsenal "keep 'em rolling".

NATIONAL LEAD COMPANY—New York, Baltimore, Buffalo, Chicago, Cleveland, Cincinnati, St. Louis; National-Boston Lead Co., Boston; John T. Lewis & Bros. Co., Philadelphia; National Lead & Oil Co. of Penna., Pittsburgh; Georgia Lead Works, Atlanta; American Lead Corp., Indianapolis; Master Metals, Inc., Cleveland; The Canada Metal Co., Ltd., Toronto, Montreal, Winnipeg, Vancouver.

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• A NATIONAL LEAD COMPANY PRODUCT •

rationing we would do it and had cards drawn up. Henderson and OPC are working on a new card and have agreed on the type."

Whether rationing will be necessary, he said, is still debateable. In some areas rubber restrictions have reduced consumption, B. L. Majewski reporting that in Chicago gasoline purchases have dropped 18 percent.

"If we get a substantial decrease it may postpone rationing," he admitted.

The coordinator emphasized the necessity of an equal distribution of transportation facilities so that the East need not suffer alone, and OPC disclosed extension of Recommendation No. 33 to the entire country.

Under the extension order, special industry subcommittees may be set up in each of the districts or in two or more districts jointly, to compile and analyze information regarding supply and demand and transportation facilities, on which plans are to be prepared to determine the amounts of crude and products and the transportation facilities available to the district involved to meet military, war industry and essential civilian needs, and provide for the exchange, loan, sale, lease or pooling of oil and products and of production, transportation, refining and storage facilities.

The subcommittees are to have authority in cases of emergency arising pending the approval of appropriate plans to coordinate and arrange for the sale, exchange or loan of oil and products among the various operators.

It was emphasized that the extension order is not to interfere with the operations of the District 5 marketing committee, acting under Recommendation No. 29, but that committee's action "should be pressed forward aggressively in a continuation of the effort to alleviate supply difficulties in Pacific Coast areas."

OPC officials disclosed that the transportation situation has already resulted in a considerable dislocation in the industry, which was evidenced by orders revising the March production recommendations issued last month.

Ickes reported that East Coast stocks continued to decline, and now are 10,744,000 barrels below those of a year ago. He disclosed also that the strain is beginning to be felt by gasoline and that "from this point on gasoline will begin to decline."

The East Coast situation has backed up oil all the way to the wells, it was revealed by orders reducing the March allowables for the Southwestern states.

While supplies in the East continue to diminish at an accelerating rate, those on the Gulf continue to pile up and it is proposed to reduce Southwestern production by approximately 10 percent from the original estimate for the current month in the effort to prevent a storage glut.

The weekly OPC report on tank car movements into the Atlantic seaboard area showed a total of 10,073 cars loaded during the week ended February 28, compared with 10,162 cars during the preceding week.

The total movement was about 2,266,425 barrels, or an average of 323,775 barrles per day, a slight decline from the preceding week's 2,286,450 barrels, or a daily average of 326,638 barrels, it was stated.

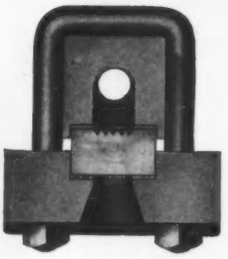
OPC officials explained that the drop in the final February week was due to the fact that many of the more than 2000 additional cars which entered service the previous week had not had time to be returned to supply points for reloading. Some of the cars, it was said, are lifting oil at points as far distant as Texas for movement to the New England area, requiring a turnaround time of 18 or 19 days.

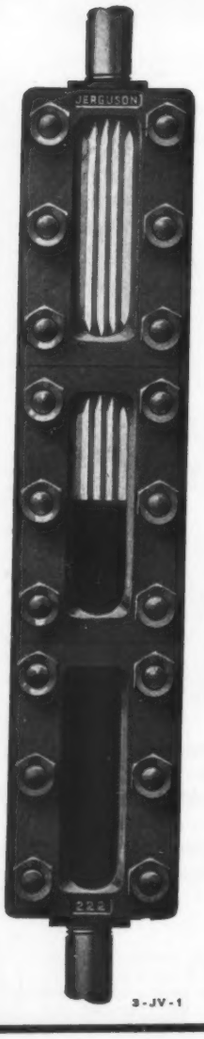
It was also disclosed on March 6 that tank-car companies have begun to convert a number of ordinary tank cars for the transportation of liquefied petroleum gases for 100-octane gasoline. Undertaken a month ago at the request of OPC, the experiment has reached a point where the first converted car received the approval of the tank-car committee of the technical division of the Association of American Railroads and was authorized for use by the Interstate Commerce Commission.

Officials Elected for Texas A. C. S. Section

M. C. Van Gundy, The Texas Company, Houston, has been elected chairman of the Southeastern Texas Section, American Chemical Society. Other new officers are: G. R. Gray, Humble Oil & Refining Company, Houston, chairman-elect; L. M. Blenderman, The Texas Company, Port Arthur, vice chairman; E. P. Doremus, Jr., Shell Oil Company, Houston, secretary-treasurer. R. H. Price, Pan American Refining Company, Texas City; A. J. Hartsook, The Rice Institute, Houston; I. S. Cliff, Shell Oil Company, Houston, were elected councillors.

The U-Bolt Assembly with Alloy and Forged Steel Parts gives Strength to . . .





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Reflex Gages

NO ONE questions the sure visibility provided by the Reflex type of gage. The other important factors are design and materials of construction. Jerguson Gages provide the best there is in gages and too much emphasis cannot be given to the strong U-Bolt assembly shown above. It's a feature of Jerguson Gages and fits them admirably for handling the high pressures often encountered in refinery circles. In fact, standard units are built for 3200 pounds pressure.

Transparent Gage

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The Jerguson Transparent Gage is ideal where the color or density of liquid must be noted. It, too, is sturdily constructed but having glass on both sides of the liquid chamber necessitates the Thru-Bolt rather than U-Bolt construction.

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87 Fellsway, Somerville, Mass.

REMOVING One Kind of Pressure
FROM WARTIME PRODUCTION

UNDER THE STRESS of the present emergency, American industry must speed up production to an unprecedented pace. Many manufacturers and refiners are removing *one kind of pressure* that slows down wartime production by installing Dowtherm*—the high temperature, low pressure, heat transfer medium.

The Dowtherm system provides accurately controlled high temperature heating and cooling. This permits shorter operating cycles and increases the capacity of the equipment.

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Segregation of Project Ratings

The necessity of segregating well-drilling equipment from plant equipment in applications for priorities on materials has been set forth in letters from Robert E. Allen, director of production, OPM. He has written to chairmen of the natural gas and natural gasoline committees of the several districts to point out that the rating for a plant which will produce aviation gasoline materials is higher than the rating on equipment for drilling, and to warn that the two should not be made on one application. His letter in one instance was:

"A large number of applications for project ratings are coming into this office which include well drilling equipment. For instance, an applicant may apply for a project rating covering the construction of a cycling plant with absorption and fractionating equipment for the production of isobutane, butane, and isopentane, and include in the same application the material for the drilling and connecting up of several condensate wells.

"We have been advised by the War Production Board that hereafter such projects will receive only the A-8 rating specified by Preference Rating Order P-98. This would very materially affect the production of aviation gasoline raw materials, as you can see. The application for the construction of the cycling plant, including the necessary equipment for production of aviation gasoline raw

"Will you please inform the industry in your district of this stand taken by the War Production Board so that they will make their project applications accordingly."

Safety Group Has Petroleum Session

The petroleum session of the annual convention of the Greater New York Safety Council, March 3 to 6, was revised and moved to March 6 on the program, which included more than 50 group sessions.

The revised program of the petroleum session included, "The Extinguishment of Incendiary Bomb Fires on Oil Properties and Protection of Personnel and Plant from Demolition Bombs," J. L. Risinger, Socony-Vacuum Oil Company, New York; "Delivering Necessary Fuels and Lubricants to Convoys on the March," J. Brooks Greenwood, The Atlantic Refining Company, Philadelphia; and a panel discussion on "Concealing Vital Targets from Air Attack," Fred Aldinger and J. W. Porter, California Texas Oil Company, New York, and J. W. Kosting, Gulf Oil Corporation, New York.

A. J. Gorand, Sun Oil Company, Philadelphia, was chairman for the session.

Cooperative Plant For East Texas

The first effort to combine selected output of several smaller refining plants for the manufacture of both 100-octane-aviation gasoline and ingredients for synthetic rubber had its start at Gladewater, Texas, last month. The move was started by the Gladewater Chamber of Commerce and resulted in conferences with officials at Washington.

The proposal is that seven refining concerns provide a minimum of 15,000 barrels of reduced crude daily, which will be processed in a combination aviation gasoline and butadiene plant, which will cost $10,000,000. Officials of the several agencies in Washington had agreed to consider a loan of that amount.

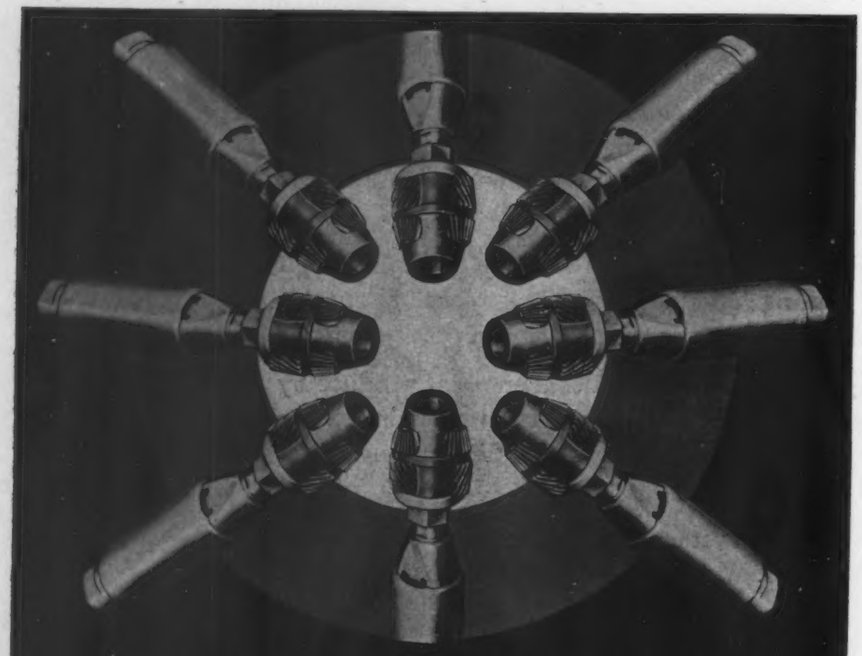
The first meeting resulted in the naming of the following committee, which will report at a later conference: T. A. Bath, Independent Refining Company, Henderson; J. D. Waddell, Skelly Oil Company, Longview; H. F. Richardson, Gladewater Refining Company, Gladewater; C. E. Wharton, Hanlon Gasoline Company, Gladewater, and Sylvester Dayson, Premier Refining Company, Longview.

The several concerns interested in the venture have plants with total capacity of 30,000 barrels daily.

Acetylene From Gas Corporation Formed

Charter has been granted for a non-profit corporation, Texas Defense Industries, Inc., which will further research into the method for making acetylene from natural gas, with acetylene to go into synthetic rubber production. The full program, however, is wider in that it will serve for the support of research in the production of materials used in national defense.

Officials are Maco Stewart, Galveston, president; John F. Camp, San Antonio, vice president; E. B. Germany, Dallas, vice president; Rueben Williams, Fort Worth, secretary-treasurer; R. E. Harding, Fort Worth and Fred F. Florence, Dallas, executive committee members.



FASTER TUBE CLEANING INCREASES REFINERY OUTPUT

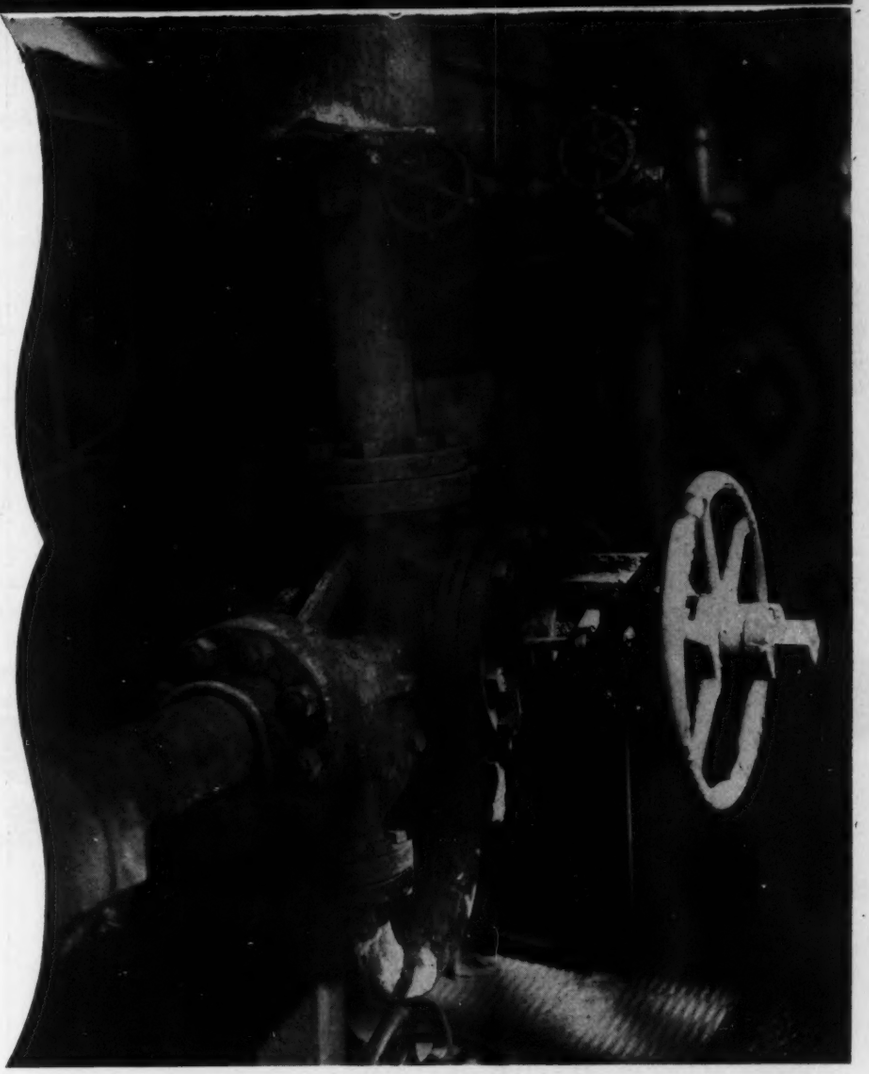
Faster production of petroleum products—gasoline, fuel and lube oils, greases, etc.—is *essential* to a successful war effort. A large proportion of the ships, planes, tanks, and other motorized equipment now being produced in greater quantities than ever before will be useless unless sufficient fuel and lubricants to operate them are produced by *our* refineries.

By cleaning refinery tubes and pipes *faster* and *better*, Wilson EP (Extra Power) Tube Cleaners reduce down-time and lengthen the time stills and other refinery units can remain on stream. No matter what kind of deposit must be removed, there is a Wilson Tube Cleaner, cutter head, or other accessory which will do the work *quickly, thoroughly, and economically.*

Write for the name of our representative nearest to you or send for a copy of our thirty-six page catalog fully describing and illustrating the complete line of Wilson tube cleaning equipment.

THOMAS C. WILSON, Inc.
PIPE AND TUBE CLEANERS EXCLUSIVELY
47-28 37th Street Long Island City, N. Y.

Here's Proof—
HOMESTEAD VALVES CAN TAKE IT!



More than twelve years of operation at **cherry red heat** on vapor lines, in one of America's leading refineries, and still going strong — is conclusive proof of "Homestead's" ability to "take it."

In this refinery, 10—4" Lever-Seald Homestead Valves control vapors from De Florez Cracking Units to coking chambers at 1120° F. and 200 pounds working pressure; while 22—8" 3-way Homesteads control vapors from the coking chambers at 250° F. and 100 pounds pressure. All of these valves have served for over twelve years—a **real** performance record!

Lever-Seald or Cam-Seald Homestead Valves are made in sizes from ½" to 12", in semi-steel, steel, Monel, Ni-Resist, brass, or other alloys for specific jobs. Consult our engineers for a solution to **your** valve problem. No obligation. And next time you order, specify "HOMESTEAD"—then watch your valve maintenance costs go down!

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HOMESTEAD VALVES

QUARTER-TURN VALVES:
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LUBRICATED TYPE
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PROTECTED-SEAT VALVES:
HYDRAULIC (B. & O. PAT.) OPERATING
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ROSS AIR SHUT-OFF VALVES
HOVALCO BLOW-OFF VALVES

Ethyl Technical Services Merged for War Activity

All technical services of the Ethyl Gasoline Corporation have been merged into a single unit which will function in close cooperation with the government, and with the petroleum and automotive industries. A war committee to adapt research facilities to the needs of the armed forces has been formed.

Julian J. Frey of Detroit, head of the company's technical sales division since 1930, is director of the new technical service department and chairman of the war committee. The department includes the gasoline-testing division, of which John Clifford Pope will be manager, and the refinery technology division, headed by William H. Hubner.

The gasoline-testing division will continue to provide sample inspection service for the company's customers, and to make periodical surveys of the quality of fuels marketed throughout the country. The refinery technology division will broaden the scope of its services in aiding refiners to attain the most economic use of tetraethyl lead.

Other divisions embraced in the new department, and their heads are: bus and truck, Errol J. Gay; passenger car and automotive accessories, Richard K. Scales; agricultural, C. G. Krieger.

Members of the war committee, in addition to Chairman Frey, are: Earl Bartholomew, Dr. George Calingaert, Dr. Graham Edgar, S. D. Heron, Dr. O. E. Kurt.

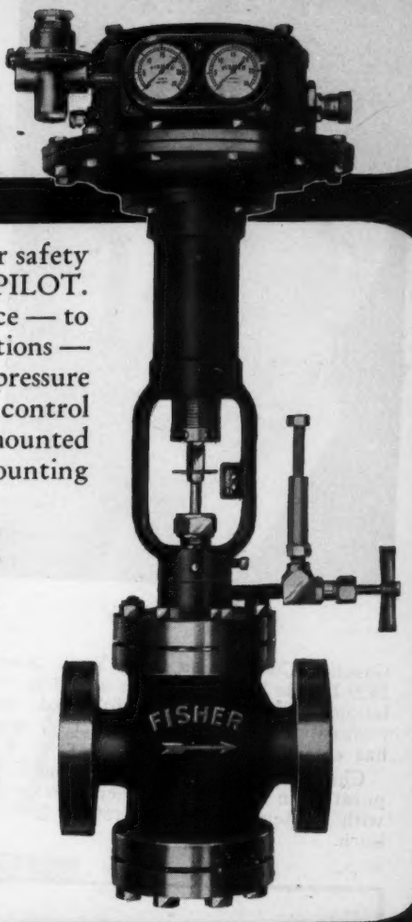
Ethyl's wartime research problems will be dealt with by a committee composed of representatives of the manufacturing department and of aeronautical, engineering, and chemical research. The members of this committee are: Bartholomew, Dr. Harold A. Beatty, Dr. Calingaert, Dr. Edgar, C. D. Hawley, Heron, Dr. Kurt, John Lachowicz, M. W. Manchester, John Schaefer.

Ralph C. Champlin has been promoted to director of advertising for the Ethyl

JOHN CLIFFORD POPE

FISHER WIZARD PILOTS

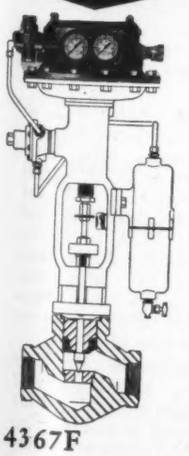
SERVE ALL PRESSURE CONTROL APPLICATIONS



For full throttling pressure reducing or relief service—safety relief or safety shut-off service — your logical choice is a FISHER WIZARD PILOT. They are applicable to standard motor valves for general service — to forged steel bodied motor valves for special high pressure applications — to butterfly valves for low pressure, large volume service—to low pressure boiler gas fuel governors — to special heavy duty, severe service control valves. FISHER WIZARD PILOTS are available in Integral mounted type for direct connected control — and in Surface or Flush mounting types for remote panel control.

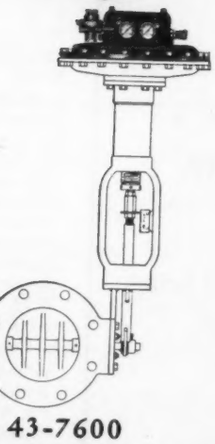
WIZARD PILOTS FEATURE

3 Different types of mounting: Integral with diaphragm casing—Surface or wall mounting — Flush or panel mounting.
Full throttling range adjustment, 1% to 75%; Vernier screw adjustment of controlled pressure setting.
Gas tight and weather proof housing for outdoor installations.
Wide range of bronze and steel Bourdon tubes for pressures up to 10,000 lbs.
Simple change-over from direct to reverse acting or vice-versa.
Simplicity of design — extreme sensitivity — absolute dependability.



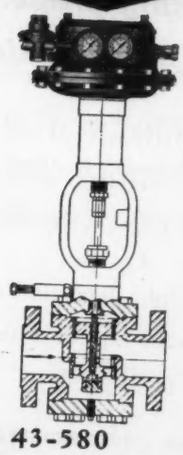
Type 4367F

Integral type WIZARD PILOT applied to forged steel bodied diaphragm control valve. Intended primarily for high pressure gas field service. Filter and auxiliary regulators are factory mounted and connected.



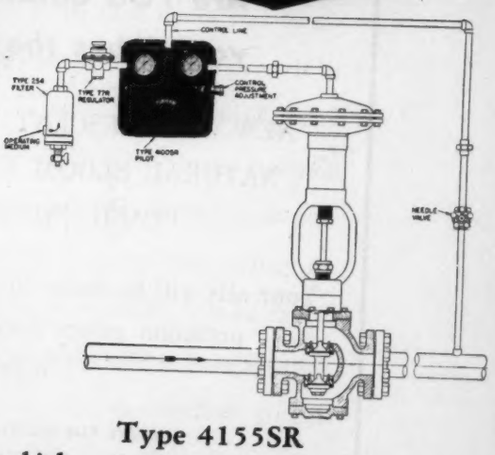
Type 43-7600

Butterfly valve assembly equipped with integrally mounted type WIZARD PILOT. Recommended for applications where it is desired to control the flow of gases under relatively low static pressures.



Type 43-580

Specially designed for high pressure relief valve service where tight shut-off is required. WIZARD PILOT mounted as integral part of upper diaphragm casing. Inner valve is piston actuated and incorporates internal pilot construction.



Type 4155SR

Surface wall mounting type WIZARD PILOT (reverse acting) with reverse acting diaphragm valve for pressure reducing service. Main valve closes on loss of operating medium pressure and closes with increasing controlled pressure.

FISHER Bulletin D gives full information on WIZARD PILOTS — your copy will gladly be sent on request.

FISHER GOVERNOR COMPANY
• FISHER BUILDING •
MARSHALLTOWN, IOWA

☆ PLANT ACTIVITIES ☆

JULIAN J. FREY

Gasoline Corporation, New York. Since 1939 he has been in charge of public relations. His promotion followed the resignation of Paul E. McElroy, who has entered government service.

Champlin joined Ethyl Gasoline Corporation in 1937, having been previously with Batten, Barton, Durstine & Osborn.

Progress of the program through which the petroleum industry will provide raw material for the annual production of 500,000 tons of synthetic rubber is such that all contracts will have been let within a month. Jesse H. Jones, Secretary of the Interior, gave this information to a sub-committee of the Interstate Commerce Committee of the House of Representatives in February. His 500,000-ton annual total is 100,000 tons higher than the output mentioned when the program began.

Some plants now under construction will be in operation within four months. The 25 to 30 plants, which largely will be devoted to production of butadiene, are due to be in operation by the end of the year. The testimony of Wright W. Gary, director of refining of OPC, was to the effect that some plants will provide ingredients for aviation gasoline and TNT as well as synthetic rubber.

One of the contracts recently announced will result in a large installation in the Texas Panhandle, where both butadiene and 100-octane aviation gasoline will be made. It will draw upon refining plants as well as natural gasoline plants for raw materials. This project is due to cost $30,000,000.

California is to have a plant of similar cost, which thus far has been considered only as a source of raw material for synthetic rubber. Location has not been announced. Several larger concerns are revamping natural gasoline plants to increase recovery of butane, one source of iso-butane for aviation gasoline as well as butadiene for synthetic rubber.

Plants are known to be under consideration for the Gulf Coast area, with two due for early announcement.

The Canadian government has announced plans for spending $40,000,000 in connection with aviation gasoline and possibly butadiene. The plant will be operated by the dominion government and will be situated near a refining center.

The Standard Oil Company (Indiana) has signed a contract with the government for the construction of a toluene plant at Whiting, Indiana. It will be in operation within a year and will produce as much of this explosive ingredient as produced in the United States during either of the World War I years. The company also has under consideration an alkylation unit as well as an isomerization unit at the Whiting works.

Premier Oil Refining Company will build a plant to cost $3,000,000 at Cotton Valley, Louisiana, with 100-octane aviation gasoline as one of its products. The concern now has a small plant there. It will enlarge this and make ready to use iso-butane from the nearby cycling plant of the Cotton Valley Operators' Committee.

Gasoline Plant: A natural gasoline plant will be constructed along with the purification and dehydrating units now under construction by the McKamie Gas Cleaning Company, McKamie field, Arkansas. The Girdler Corporation, Louisville, Kentucky, is proceeding with design and erection of purification and dehydration units, which will treat the gas which has 4500 grains of hydrogen sulfide per 100 cubic feet of gas as well as 5 percent carbon dioxide. It will be brought to specification of the Bureau of Standards. Later it is planned to add facilities for converting hydrogen sulfide to elemental sulphur, sulphuric acid or some other useful product.

Atlas Reorganization: Atlas Oil & Refining Corporation has been formed in reorganization of Atlas Pipe Line Corporation, which has a 10,000-barrel refining plant at Shreveport. The latter company was under receivership and trusteeship from May, 1939, until the reorganization last month. Pipe lines connect the plant to the Magnolia, Arkansas, field and with the East Texas field. Oil producers in these areas as well as Mississippi are stockholders.

Treating Plant: Lakeside Refining Company, Kalamazoo, Michigan, will build a 600-barrel catalytic treating unit for handling straight-run gasoline. The Perco Division, Phillips Petroleum Company, Bartlesville, Oklahoma, is licensee for its desulfurization process.

Times like these demand EFFICIENCY!

Are YOU obtaining proper cast for your lubes the most efficient way?

NEW FLUORESCENT GREEN H W PRODUCES A NATURAL BLOOM WITHOUT AFFECTING FIRE, FLASH, POUR OR CARBON TESTS

Your oils will be stable to light, heat and storage — and bring premium prices because of their uniformity and high performance

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"Blood . . . Sweat . . . Tears"

and Progress!

Through "blood and sweat and tears" was built the mighty, progressive nation we know today. In our own lifetime we can look back but a short 25 years to another war. Even then minds had barely conceived the giant airplanes that now carry passengers and mail over oceans and continents. It is through hardship and necessity that the dreams of all the yesterdays have become today's commonplace but indispensable realities. ¶ The petroleum industry has had no small share in the nation's progress, particularly during the last quarter century. Where gasoline stations once served hundreds and thousands, they now serve millions. No day passes but what recent progress in petroleum makes its influence felt. ¶ Peace will come again to America. Then you in the petroleum industry will be called upon for even greater contributions and achievements. War effort necessarily claims your greatest attention now. But out of it all will emerge the experience and knowledge that foreshadows greater progress for peace. ¶ OHIO, too, is gaining invaluable experience from the war effort. In producing to serve the highest priority ratings, to which even our greatly expanded output is necessarily restricted, we are meeting the exacting standards of materials and workmanship demanded by Army and Navy specifications. ¶ After "blood and sweat and tears" comes progress. Ohio Seamless Tubing engineers are keeping abreast of developments in the petroleum industry.

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SCIENCE AND TECHNOLOGY

Abstracts prepared in co-operation with the

REFINER AND NATURAL GASOLINE MANUFACTURER

by

THE LESLIE LABORATORIES

Traver Road, Ann Arbor, Mich.

under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

Expansion of Crude Petroleum, Petroleum Products and Allied Substances, Report of Institute of Petroleum Sub-Committee J, Sampling and Measurement, *Jour. Inst. Petr.* **27** (1941) pp. 402-17.

Sub-Committee J, Sampling and Measurement, of the Institute of Petroleum, was appointed to deal with questions relating to the measurement of oil in bulk, and accordingly investigated the subject of the expansion of petroleum, and petroleum products. Data were collected on 179 different materials. The data were collected from numerous sources and reduced to a common basis. Tables are presented which include American oils and also all of the miscellaneous information collected by the Committee. The Committee concludes that the data given in the tables indicate that the National Standard Petroleum Oil Tables of the U. S. Bureau of Standards, Circular C 410, published in 1936, are applicable, to the degree of accuracy required in commercial transactions, to a large number of materials in addition to the American oils on which the construction of the tables was based. They conclude that an effort to provide tables of more general applicability than C 140 would not be justifiable.

Some Heat Capacity Data for Gaseous 2, 2, 4-Trimethylpentane, M. KIPERASH AND G. S. PARKS, *Jour. Amer. Chem. Soc.* **64** (1942) p. 179.

The authors report five determinations of the molal heat capacity at one atmosphere pressure of gaseous 2,2,4-trimethylpentane. These are found to check reasonably well the recently reported single experimental value of Pitzer. For comparison they calculate the values for C_pO by Pitzer's general empirical equation for gaseous paraffins, which equation, Pitzer has suggested, is probably applicable to the branched paraffins as well as to the normal compounds. The authors suggest that the results for this equation will run a little low in the case of this highly-branched compound. In passing, they note that the heat capacity values calculated for 2,2,4-trimethylpentane by the semi-theoretical methods of Bennewitz and Rossner are of the order of 10 percent low, or more, as Pitzer likewise found in the case of n-heptane.

The Heat Capacity, Entropy, Heats of Fusion, Transition, and Vaporization and Vapor Pressures of Methyl Mercaptan, H. RUSSELL, JR., DARRELL W. OSBORNE AND D. M. YOST, *Jour. Amer. Chem. Soc.* **64** (1942) pp. 165-69.

The heat capacities of solid and liquid methyl mercaptan have been measured over the temperature range 14.273° K. There is a slow isothermal transition at 137.6 ± 0.1° K., the heat of transition being 52.5 ± 0.5 cal./mole. The melting point of pure methyl mercaptan is 150.16 ± 0.02° K., and the heat of fusion is 1411.4 ± 2.0 cal./mole. The vapor pressure was measured in the range 222.279° K., and can be accurately represented by the equation $\log_{10} P_{mm} = 18.2749 - (1769.05/T) - 3.70248 \log_{10} T$; the boiling point from this equation is 279.12° K. (5.96° C.). The directly measured heat of vaporization at the normal boiling point is 5872 ± 4 cal./mole. The entropy of methyl mercaptan at one atmosphere and 279.12° K. is 60.16 ± 0.10 cal./deg./mole for the ideal vapor. Comparison of this value with that calculated from molecular data leads to a barrier of 1460 ± 270 cal./mole restricting the rotation of the methyl group.

The Heat Capacity, Heats of Fusion and Vaporization, Vapor Pressure and Entropy of Dimethyl Sulfide, D. W. OSBORNE, R. N. DOESCHER, AND D. M. YOST, *Jour. Amer. Chem. Soc.* **64** (1942) pp. 169-72.

The heat capacity of dimethyl sulfide was determined over the range 13.3-292° K. The melting point is 174.86 ± 0.02° K., the heat of fusion is 1908.4 ± 1 cal./mole, the directly measured heat of vaporization is 6688 ± 7 cal./mole, and the vapor pressure can be represented by the equation $\log_{10} P_{mm.} = 16.51798 - (1876.370/T) - 3.04727 \log_{10} T$ over the range 250.6 — 290.2° K. (0° C. = 273.16°K.). From the calorimetric data the standard entropy of the ideal gas is 67.37 ± 0.1 and 68.28 ± 0.1 cal./deg./mole at 291.06° K. and 298.16° K., respectively. The entropy of the liquid at 298.16° K. is 46.94 ± 0.07 cal./deg./mole. Comparison of the experimental and statistical entropies of dimethyl sulfide leads to a barrier potential of 2000 cal./mole hindering the rotation of each methyl group.

Heat Transfer of Condensing Organic Vapors, A. H. COOPER, R. H. MORRISON, AND H. E. HENDERSON, *Ind. & Eng. Chem.* **34** (1942) pp. 79-84.

The authors point out that few data are available on the condensing of vapors other than steam. In their investigation they made an effort to determine and correlate the film heat transfer coefficients for organic vapors condensing on a vertical surface. The investigation included primarily a study of two series of organic liquids, alcohols, and acetates. Five members of each of these series (methyl through amyl) and in addition a constant-boiling mixture of ethyl acetate-isopropyl alcohol and an immiscible liquid mixture of steam and butyl acetate were studied. Members of each of the organic series investigated fell in parallel curves, the film coefficients decreasing with increasing molecular weights. The film coefficients of the condensing immiscible liquid mixture fell between the two pure components, while that of the azeotropic mixture appeared to be higher than either of the components. The data are presented in detail in tabular form, and also in graphical form. In general the film coefficients decrease rather rapidly with increase of temperature difference up to a temperature difference of 20 to 30° F. After this the decrease with temperature difference is slower and follows an almost straight-line relationship. The experimental values found were considerably higher than those calculated from the Nusselt equation. A bibliography of 31 references is included.

Surface Energy of Lubricating Oils, L. A. STEINER, *Petroleum (London)* **4** (1941) pp. 123-27.

Of the previously-made investigations in the field of surface forces in mineral oils, only Winchester and Reber made point-by-point measurements for lubricating oils over a wide temperature range. They found a rectilinear relationship between 80° and 320° C. for six oils. In the investigation reported by the author, the free and total surface energy between 20° and 100° C. for 6 widely different oils were obtained. A rectilinear relationship was found in some cases, and a curvilinear in others. A method was developed for the measurement of surface forces that eliminates the influence of viscosity upon the results of the measurements. The apparatus used was similar to a Steiner viscometer but relatively wide tubes were used so that the effect of surface energy could be neglected. By use of a suitable procedure it was possible to measure both the viscosity and the variation of surface energy with temperature. The degree of accuracy was 0.3 percent for viscosity and 0.03 erg/cm.² for surface energy. The surface energy of lubricating oils toward air at 20° C. lies between 28 and 35 erg/cm.², confirming the known fact that the surface tension rises with both density and viscosity. Little is known about the solubility and saturation limit of liquid viscous hydrocarbons in each other, and some types of oils have been observed to be incompatible with each other. Those oils showing a curvilinear surface energy relationship probably contain components that are not mutually soluble to completion.

Chemical Composition And Reactions

The Photochemistry of Isobutene. I, W. F. KIEFFER AND J. P. HOWE, *Jour. Amer. Chem. Soc.* **64** (1942) pp. 1-7.

The investigation was undertaken to observe the direct action of light on the isobutene molecule and in particular to attempt to determine the mechanism of its gas phase photochemical polymerization. The effect of approximately monochromatic radiation from the aluminum spark, about 1900 A., on isobutene was studied. Both decomposition and polymerization occur, and in the region of maximum rate quantum yields were: hydrogen 0.03; methane, 0.10; hydrocarbon with 2.25 carbon atoms per molecule, 0.16; polymer with 9.05 carbon atoms per molecule, 0.45. A free radical mechanism is required for some of the processes, and, moreover, is capable of accounting for all of the observed processes. The essential features are: that at low pressures the most important reactions are splitting of the excited isobutene molecule into primary free radicals which recombine in the gas phase and on the wall, some of them reacting with isobutene molecules. At higher pressures, the excited molecules are quenched to a large extent, the radicals that are formed reacting chiefly with isobutene to form other radicals that eventually combine. The nature of the wall has an influence on the reaction. No methyl-acetylene could be found so that little analogy with the effect of light on ethylene exists.

Manufacture: Processes And Plant

Petroleum's Past, Present and Future, R. P. RUSSELL, *Chem. & Met. Engr.* **49** (1942) pp. 84-5.

The author contrasts petroleum, from a tonnage basis, with some of the other industries so often regarded as outstanding examples of American mass production methods. The industry processes 200 million tons per year of crude oil, and makes approximately 90 million tons of gasoline. For comparison, the steel industry, which is generally looked upon as the greatest of the "tonnage" industries, in 1941 made 84 million tons of steel, which sold for approximately $38 per ton at the mill, as compared to $16 per ton for gasoline as it leaves the refinery. Aviation

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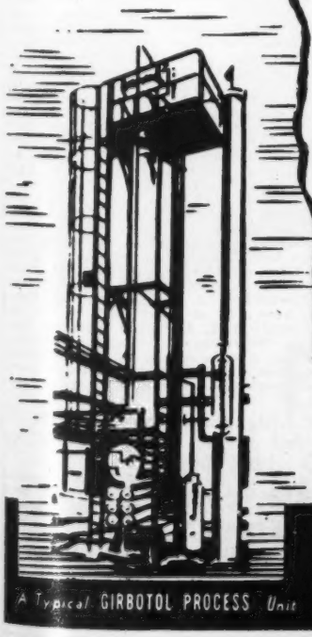
GAS FACTS IN SO. ARKANSAS FIELDS

FIELD	CLASS	H_2S GRAINS per 100 cu. ft.	CO_2% by volume
SCHULER	Oil & Gas	30	4.9
ATLANTA	Oil & Gas	860	.....
VILLAGE	Oil & Gas	1500	6.2
MAGNOLIA	Oil & Gas	1500	3.4
BIG CREEK	Gas	360	.....
MACEDONIA	Gas	2400	2.0
DORCHEAT	Gas	1945	4.3
McKAMIE	Gas	4500	.....
PATTON	Gas	9000	.....

FROM OIL & GAS JOURNAL



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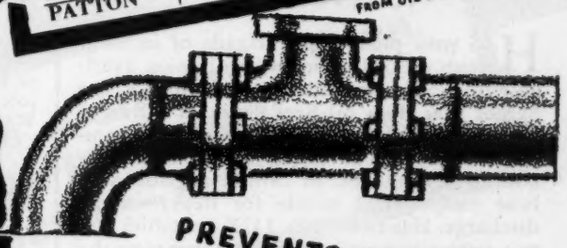
Girbotol Process not only removes the high H_2S content from McKamie gas, making it commercially salable—but CO_2 is removed simultaneously—which increases the heating value of the gas!



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HAS your plant a fire brigade of its own, with centrally located equipment available for quick action? Looking for a fire fighter that slaps oil fires down in a hurry?

If the answer's *yes,* we'll paint your company's name on a new LUX Trailer Unit. This one carries 300 lbs. of carbon dioxide with hose reel, special nozzle for heavy-volume discharge. Has two 20-lb. LUX portables and two pure-water extinguishers to complete the armament against smaller blazes.

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WHAT ABOUT WATCHMEN?

Watchmen must be courageous, fit, and have no physical disability.

Two of America's most spectacular fires last year were caused by careless watchmen who muffed their jobs. Who stands guard in your plant? Is he alert, strong, responsible? If he's infirm, aged, or irresponsible, find him another job. Hire a good man in his place. Watchmen are vitally important!

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Small in size, strong in its fire-killing wallop is the Kidde-LUX 4-pounder. It is designed to extinguish those tricky small-area blazes in chemicals and flammable liquids which must be snuffed out fast.

Trigger-control features the Kidde-LUX. Aim at the blaze, pull the trigger . . . and socko! A blast of carbon dioxide snow-and-gas smothers the fire *quick!*

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gasoline, which is a material containing about 50 percent of a synthetic organic chemical, was produced to the extent of approximately 2,500,000 tons of 100 octane number gasoline in 1941, and will be produced at perhaps 7,000,000 tons per year by the end of 1942. This compares with an annual production rate for aluminum, for example, of 600,000 tons in 1942 if present hopes are realized. The technical complexity of the operations involved in the petroleum refining is indicated by the fact that the industry employs a little more than 10 percent of all the research and development workers in the United States. Since 1927 the number of technical people employed in the oil industry has increased sevenfold. This compares to a three-fold increase in the chemical industry, and a two-fold increase in the rubber industry. The petroleum industry has built a chemical business producing a volume of products well in excess of $100,000,000 per year value. This includes such products as alcohols, glycols, ketones, aldehydes, organic acids, plastics, solvents, and synthetic rubber. This industry is in the process of rapid and important expansion. The author discusses price trends for the products produced by the industry. In reviewing what is ahead he notes that, within the next two or three years, it is expected that catalytic cracking units capable of treating something in the order of 500,000 barrels per day of charging stock will be in operation. These will produce 250,000 barrels per day of extremely high octane number gasoline, whereas the present requirements for premium grade motor gasoline during 1941 was only approximately 180,000 barrels per day. Since aviation gasoline requirements will drop sharply for some period following the cessation of hostilities, there will be available a large quantity of high grade gasoline that will permit the design of engines that can take full advantage of the better gasoline quality to increase economy and power output. The author believes that there will be a tremendous increase in the utilization of newer and more intricate catalytic operations, and a great expansion in chemicals produced from petroleum, all of which will make the petroleum industry a tremendous user of technical manpower.

War-Time Protection of Industrial Plants, *Chem. & Met. Report, Chem. & Met. Engr.* **49** (1942) pp. 101-8

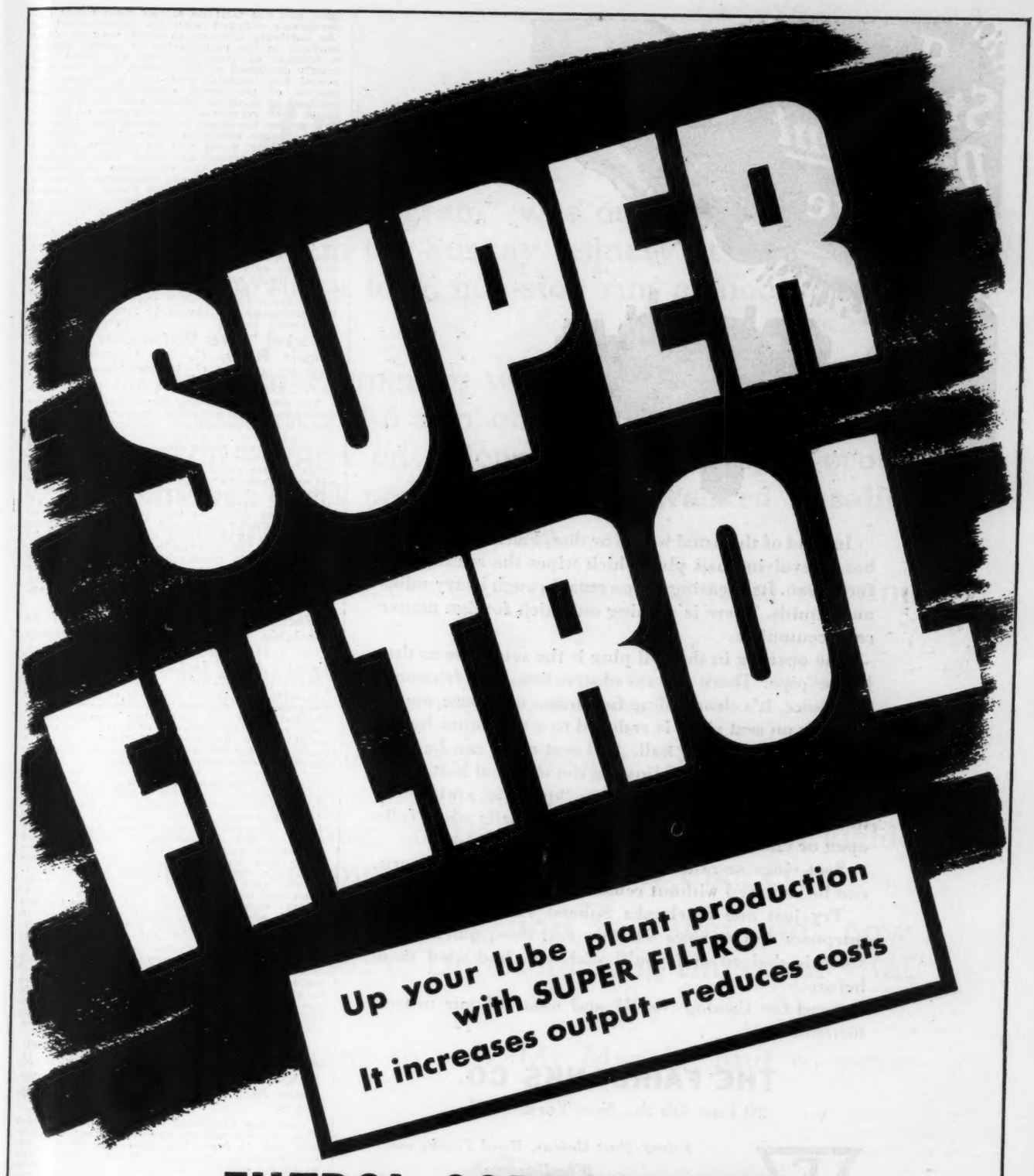
The article discusses protection against sabotage, incendiarism, and air raids. The methods used in sabotage are outlined, including sabotage by fire. Fire prevention, sabotage prevention, protective fencing, fence lighting, and the handling of sabotage bombs, are all considered. Incendiary bombs are discussed in some detail, with a discussion of methods for coping with them. The article includes a bibliography of publications by the Office of Civilian Defense that will be of interest to plant men.

A Work-Week Plan for Chemical Industry, R. R. LYMAN AND D. F. OTHMER, *Chem. & Met. Engr.* **49** (1942) pp. 86-7.

With the labor situation becoming steadily more complicated by federal and state laws, and in view of Washington's call for doubled and quadrupled production of war materials the Gray system of scheduling continuous shift work is now worth special consideration. This progressive rotation system for four shifts on a 32-hour cycle and a 168-hour work week has stood the test of four years of continuous use and comparison by actual operation with numerous other plans. The authors state that no other plan approaches it in advantages. The Gray plan is really based on the substitution of new time units for the usual ones: instead of a 24-hour day, a 32-hour cycle, i.e., four 8-hour shifts, is used; instead of a seven-day week, a four-day rotation; and instead of a calendar month, four weeks (28 days of seven rotations) which period acts as a common denominator of days, shifts, cycles and weeks. The Gray plan of progressive rotation follows the simplest possible pattern. A man works eight hours, is off 24 hours, and repeats indefinitely without change. No relief men are required. Every man always has three out of four Sundays off. No long shifts on or short periods off occur, and no weekly change of shifts with accompanying disruption of sleeping habits. Every man may have off at least half of the day time everyday; and desirable sleeping time every night. Overtime is reduced to theoretical minimum and bookkeeping is minimized. The same men always work together everyday. Supervisors see every man at least every four days.

Patent Litigation in 1940 and 1941, N. LITTELL, *Ind. & Eng. Chem.* **34** (1942) pp. 88-92.

The last two years in the field of litigation concerning patents and their uses have been characterized by numerous suits and prosecutions under the antitrust laws to stop alleged improper uses of patents for the control of prices and competition. The effect of this litigation has been to clarify somewhat the border line between lawful and unlawful exercises of patent rights under the antitrust laws, but it may be said that there still remain many conflicts between existing "court



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It can be opened or closed as "quick as a wink" by the long lever handle. A positive stop tells when fully open or closed.

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law" and the attitude of the government departments charged with the enforcement of the antitrust laws as to what may be done lawfully in the exploitation of patent rights. A number of court decisions are cited and briefly discussed by the author. The two-year period has likewise witnessed a further extension of the strict construction doctrine outlined in previous decisions of the Supreme Court with reference to the degree of inventive genius necessary to sustain the claim to a patentable invention where the invention is admittedly novel and has utility. Several illustrative decisions are cited. Two decisions with reference to the correction of patents by reissue are given and discussed. The author states that while the trend of recent decisions of the Supreme Court appears to be adverse to patents, it must be borne in mind that most patent cases get to the Supreme Court by virtue of conflicting decisions on the interpretation of the patent by two or more Circuit Courts of Appeals, and that therefore only those cases in which there is serious doubt as to validity are normally considered by the Supreme Court. There is no justification for the view that patents are to be considered less favorably today than forty years ago.

Packed Tower Performance at High Liquor Rates, C. M. COOPER, R. J. CHRISTL AND L. C. PEERY, *Trans. Amer. Inst. Chem. Engrs.* **37** (1941) pp. 979-96.

The effect of gas and liquor rates upon the performance of a packed tower with 2-inch rings was investigated. Carbon dioxide was stripped from its water solution by air in a 30-inch square tower filled to a depth of 86 inches with 2 x 2 x 1/16-inch steel Raschig rings. Water rates from 13,200 to 56,000, and air rates from 19 to 368 lb./(hr.) (sq. ft.) were employed. At constant water rate the values of H.T.U. were found to vary with the air rate by as much as two fold, increasing as the gas velocity decreased. The average linear water velocity down the column exceeded by several fold the average linear gas velocity up. This results in circulation of the gas within the column from top toward bottom, thereby altering the true counter-current relationship. The data are presented in some detail in tabular and graphical form.

Rectification in the Presence of an Insoluble Component. E. M. SCHOENBORN, J. H. KOFFOLT, AND J. R. WITHROW, *Trans. Amer. Inst. Chem. Engrs.* **37** (1941) pp. 997-1021.

Rectification in the presence of an insoluble component is frequently encountered in the distillation of oils and other organic chemicals, as in the presence of steam, in steam stripping, in azeotropic distillation, and in apparatus for so-called hydro-selection. Despite its commercial importance, no definite studies appear to have been made as to the diffusional resistance of an extra component in the vapor or an extra phase in the liquid, although limited information has been available. As a start in the systematic investigation of this field of distillation, a study was made of the distillation of water-insoluble compounds with the addition of steam to the vapor and water to the liquid, the latter forming a second liquid phase. Normal distillations were conducted without these additions, and for purposes of comparison. Experiments were made in typical semi-works packed and plate columns, and also in a three-plate glass column for purpose of observation. The results obtained showed that for steam concentrations up to 2.23 moles of steam per mole of solvent and for water concentrations up to 7.92 moles of water per mole of solvent, no decrease in effectiveness in the packed column or plate efficiency in the plate column were observed. An interpretation of the results is given in terms of the effect of the extra component on performance.

Performance of Refinery Gas Absorbers with and without Intercoolers, R. M. JACKSON AND T. K. SHERWOOD, *Trans. Amer. Inst. Chem. Engrs.* **37** (1941) pp. 959-78.

Data are presented in the plant operation of a 19-plate refinery absorber 9 feet in diameter and 71 feet high, operating at 6.25 atmospheres on cracking coil gas. Results are given for summer and winter operation with and without an intercooler connected near the middle of the tower. Illustrative calculations are given for the prediction of tower operation under the test conditions, and a comparison of the results of the calculations with those from the plant show good agreement between calculated and observed values for recoveries of the various components. The data are presented in useful detail. The effectiveness of the intercooler is clearly shown. The observed plate officiency varied with the component absorbed.

Theory of Open-Tube Distillation Columns, J. W. WESTHAVER, *Ind. & Eng. Chem.* **34** (1942) pp. 126-30.

The author outlines the equilibrium theory of the open-tube form of column and com-

Tuning up for war

The "defense program" was on when the Dubbscracking unit in the Sunray refinery at Allen, Oklahoma, started a long, non-stop run at noon on August 5, 1941

The defense program was still on when the unit was shut down at 6 a. m. on November 18, after running 2514 hours on Allen crude and topped crude, producing 62.81 percent of Dubbscracked gasoline — a remarkable performance

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Now it's an all-out war program Sunray's Dubbs unit and Sunray's organization are tuned up for war production Long, continuous runs and high yields of gasoline are more important now than ever

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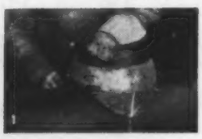
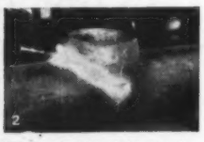
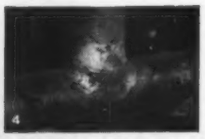


Mark center lines and tack the fitting into place.



Then weld the fitting to the main pipe.

Remove the button, which will also permit inspection of inside of joint.



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pares its theoretical performance with existing experimental data. The open tube was chosen for analysis in preference to more complicated structures because the fewer variables enable a more certain identification of those factors in the liquid-vapor transfer process that limit the column efficiency. The theory of the open tube can serve as the basis of a theory for packed tubes by noting certain correlations between the two types. The turbulent nature of the flow through a packing appears to produce an effective vapor diffusion coefficient reaching as high as ten times that for the laminar vapor stream of a smooth open tube. This in itself confers a tenfold advantage on turbulence-producing structures since, as will be seen, the vapor diffusion coefficient is an important efficiency-limiting factor. For total reflux and ideal reflux conditions, the H.E.T.P. of an open-tube distillation column is found to be (11/48) $v_a r_0/D + D/v_a$, where v_a is the radially averaged velocity, r_0 the radius, and D the molecular diffusion coefficient, of the vapor stream. This relation fixes the minimum H.E.T.P. at 0.96 r_0; the corresponding vapor velocity is below the range of existing experimental data. At ordinary velocities the theoretical and certain experimental H.E.T.P.'s are in good agreement. This indicates that ideal reflux conditions have been obtained. The H.E.T.P. can be reduced below that given by the formula but only by inducing vapor turbulence. The increase in H.E.T.P. due to sampling and temperature-gradient instability is discussed. The results of the theory indicate the possibility of obtaining an experimental H.E.T.P. less than 1.0 cm.

Nomograph for Flow from Partially Filled Pipes, D. S. DAVIS, *Ind. & Eng. Chem.* **34** (1942) p. 52.

A nomograph is presented for the flow from partially filled pipes. A line is drawn from a point corresponding to the nominal diameter, in inches, of the pipe, to a second point, which is the fraction of the diameter represented by the depth of liquid in the pipe. The intersection of this line with a third vertical line reads the gallons per minute flowing through the pipe. Derivation of the nomograph is given in the article.

Agitation. Performance of Propellers in Liquid-Solid Systems, A. W. HIXSON AND S. J. BAUM, *Ind. & Eng. Chem.* **34** (1942) pp. 120-25.

Previously derived relationships are applied to a study of the rate of dissolution of solids in liquids in a series of geometrically similar vessels fitted with propeller stirrers. It was found that the dissolution constant, K, for any particular liquid-solid system under isothermal conditions is a function of the product of speed and size factor, nd, and this relation holds for several different agitator designs. The results for four liquid-solid combinations in propeller agitators over a temperature range of 6-45° C. are correlated by the equation:

$$\frac{Kd}{D} = 3.5 \times 10^{-4} \left(\frac{nd^2\rho}{u} \right)^{1.0} \left(\frac{u}{\rho D} \right)^{0.5}$$

The methods and results indicate the utility of model experiments in prediction of agitator performance. A comparison was made between the turbine and propeller as an agitating device, and for the range of sizes studied, the turbine, operating without baffles, gives higher values for the dissolution constant in liquid-solid agitation. Data are presented in some detail in tabular and graphical form.

Multi-Layer Construction of Thick Wall Pressure Vessels, T. M. JASPER AND C. M. SCUDDER, *Trans. Amer. Inst. Chem. Engrs.* **37** (1941) pp. 885-909.

The application of high operating pressures in the chemical industries has been steadily increasing during the past twenty years with the result that the ingenuity and resourcefulness of pressure vessel manufacturers have constantly been taxed to meet the industry's needs. One of the outstanding contributions is the Multi-layer vessel, which offers a construction of relatively thick walls as a solution to the pressure problem. Such vessels have been built for about ten years, and used in the chemical and petroleum industries at pressures up to well over 5000 lbs. per square inch. The authors describe the development of this method of fabricating vessels. The article is interestingly illustrated to show methods of construction. An important fact is that the innermost layer can be made of any corrosion resistant material, and all the other layers can then be made from the most economical materials for resistance to temperature and pressure. Multi-layer construction is particularly applicable to small diameter, heavy wall vessels. The largest vessel built to date weighed 313,000 pounds, had an inside diameter of 48 inches, a length of 45 feet, and a wall thickness of 8½ inches. Design formulas are discussed, as well as making the end closure, and subjects of location of openings.

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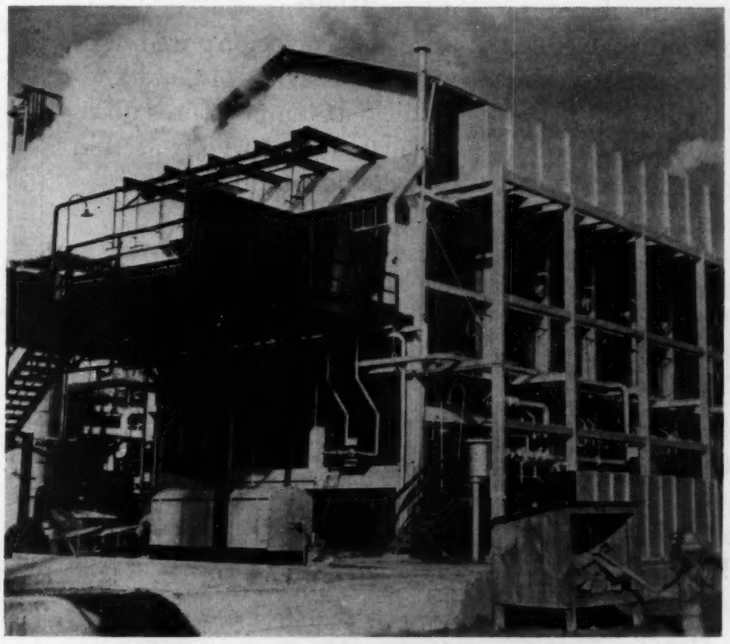

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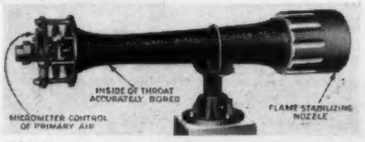

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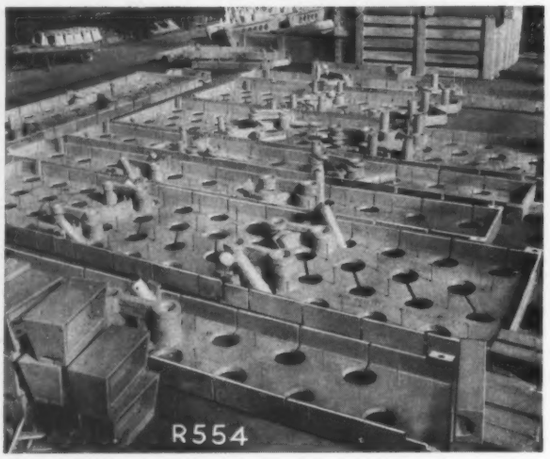

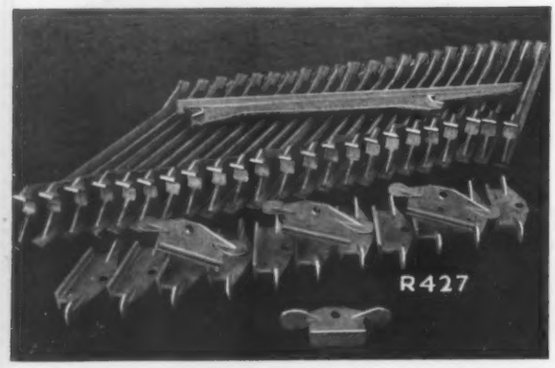

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Products: Properties And Utilization

Hydrocarbon Solvents from Petroleum and Their Industrial Applications, F. N. HARRAP AND E. B. EVANS, *Jour. Inst. Petr.* **27** (1941) pp. 369-98.

The authors note that there is a quite extensive literature on solvents generally, but no comprehensive discussion on the properties and applications of petroleum solvents, therefore they present a general description of the commonly available petroleum solvents and the way in which they are used, feeling that this may be of interest both to the petroleum technologist and to the users of such solvents. Prior to the war, a large number of petroleum solvents were available, but in the interests of conservation of supply and effort the number of grades has been reduced to a few main types. These cover a range of six Special Boiling-Point Spirits (S.B.P.'s Nos. 1 to 6), Pool Rubber Solvent (R.S.), Pool White Spirit and Pool Distillate. This range of materials has proved adequate in practice for the basic needs of industry. Methods of production of the special petroleum solvents are briefly described, including the batch method and a typical continuous method. Specifications and properties of the various solvents are next given. The properties include flash point and inflammability, vapor pressure, latent heat of vaporization, specific heat, viscosity, freezing point, composition, solvent power, and physiological action. The application of petroleum solvents is next described. These may be divided into three classifications: (a) extraction processes for oils and fats; (b) deposition processes in which the petroleum products are used as thinners or diluents in solution to give films of resins and the like; and (c) miscellaneous applications. Under extraction processes the applications in oil-seed extraction, perfume extraction, glue manufacture, dry cleaning, in leather processing, and in other miscellaneous extraction processes, are described. Under deposition processes the author includes descriptions of the uses of petroleum solvents in the rubber industry, in making cellulose lacquers, in producing printing inks, in making paints and varnishes, in the manufacture of polishes, and in miscellaneous applications.

Measurement of Oxidation Stability of Road Asphalts, A. P. ANDERSON, F. H. STROSS, AND A. ELLINGS, *Ind. & Eng. Chem., Anal. Ed.* **14** (1942) pp. 45-49.

Two test methods are described for determining the oxidation stability of asphalts, to enable forecast of their road behavior. The first method is rapid and can be used for routine testing of asphalt shipments. It uses data obtained by means of the standard loss on heating test. In the second, and more accurate method, an asphalt solution in benzene is subjected to the action of oxygen at an elevated pressure but at a temperature within the range of those found in service. No volatilization of asphalt constituents occurs. This method is designed for testing unknown asphalt. A number of representative asphalts have been classified by these methods in comparison to their road performance. A bibliography of 20 references is included.

Electrical Stability of Mineral-Oil-Treated Dielectrics, F. M. CLARK AND E. L. RAAB, *Ind. & Eng. Chem.* **34** (1942) pp. 110-16.

The suitability of mineral oil for use as an impregnant of cellulose dielectrics is best gaged by a study of the treated insulation. "Beaker" studies of the oil are frequently misleading. The common danger in the manufacture of mineral impregnating oils for dielectric use is that of overrefining. This results from the fact that the chemical and dielectric properties of the oil, per se, improve with exhaustive acid treatment of the distillate, in contrast to the behavior of the oil-impregnated cellulose insulation which reaches its maximum dielectric stability after only a limited refining treatment. The object of the refining treatment is to eliminate as completely as possible the olefin type of chemical unsaturation in the crude oil without severe reduction in its aromatic unsaturation. For the type of distillate studied, the greatest dielectric stability of the treated insulation is obtained when the aromatic unsaturation content of the oil is in the range from 22 to 23 percent corresponding to a specific dispersion value of 115 to 117. To acid refine the distillate oil to its greatest impregnating dielectric stability, the treating temperature is preferably around 20° C., and 96 percent concentrated sulfuric acid is used in the ratio of 3.5 to 5.5 pounds per gallon of oil. Increased treating temperature, with or without variation in the concentration and the amount of acid used, yields a product of inferior qualities when the dielectric stability of the impregnated cellulose is studied. The

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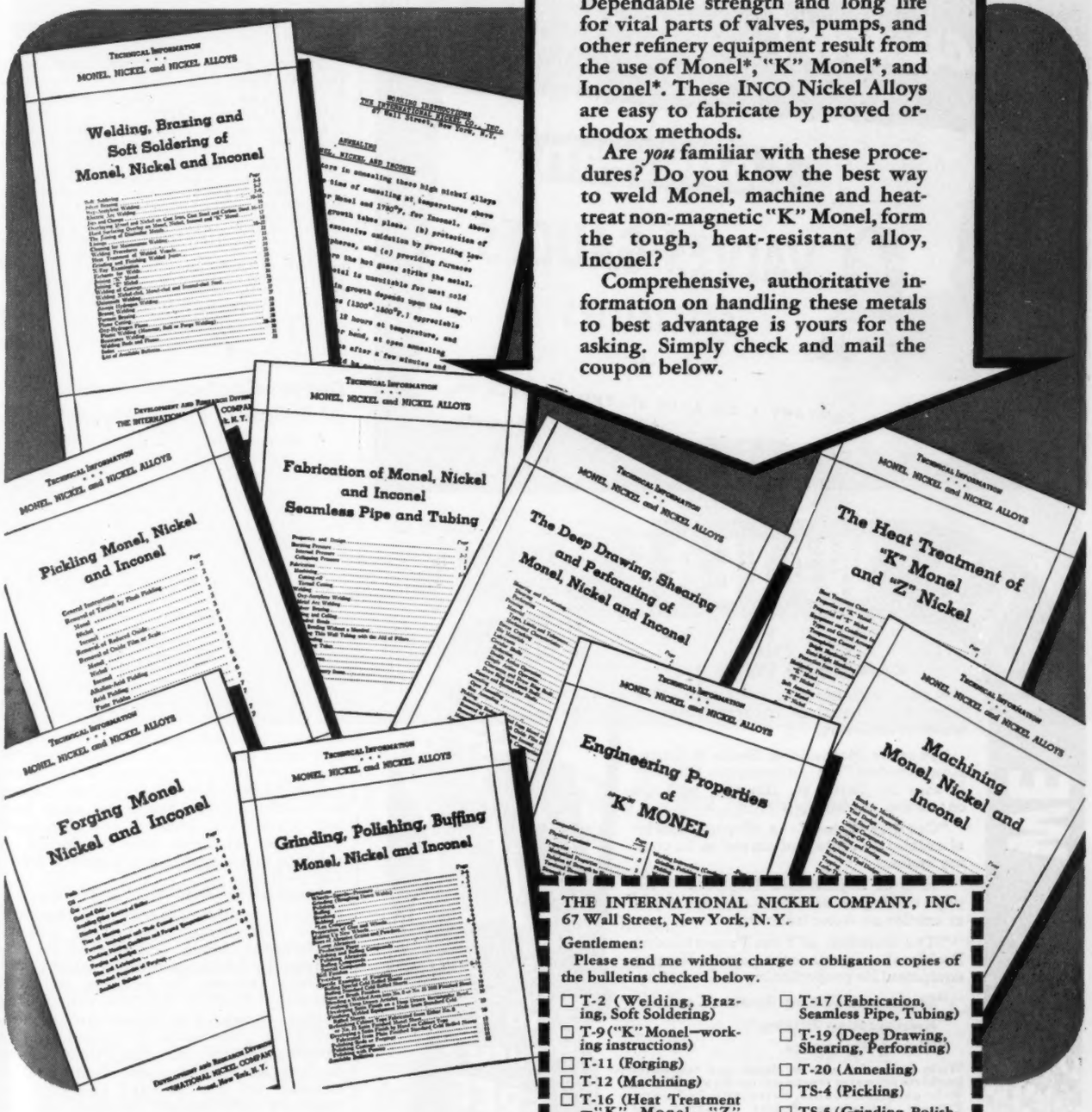
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use of adsorbents in the refining of insulating oils is briefly discussed.

Petroleum Resin Emulsions, E. S. PAICE, *Ind. Chemist,* December, 1941.

The petroleum industry has in recent years come to the fore in the resin field, and is now able to offer an impressive array of materials which the paint industry can use to advantage. Thus the light colored petroleum resins obtained from certain crudes have recently found application in the manufacture of camouflage paints for factories, aerodromes and barracks. Certain aromatic extracts obtained from the refining of lubricating oil have also proved suitable. Naphthenic acid is now well established in its use for the preparation of metallic naphthenate driers. The author discusses camouflage finishes, preparation of petroleum resin emulsion paints, and includes a brief description of types of emulsifiers and manufacturing methods.

Aniline Point Determinations with Dark-Colored Oils, A. A. WILLIAMS AND E. W. DEAN, *Ind. & Eng. Chem. Anal. Ed.* **14** (1942) pp. 63-4.

When the aniline point of dark oils is to be determined visual observation fails to detect turbidity in layers of liquid 20 to 25 mm. thick. Other methods have been proposed and used. These are briefly reviewed by the authors, who then describe a circulating test tube method devised by them. By this method oils can be tested that are not absolutely opaque when dissolved in an equal volume of aniline and observed in layers approximately 2 mm. thick. It has proved entirely adequate for existing needs with the simple accessories described in the article, and is considered more convenient and accurate for light-colored oils than the apparatus prescribed by the A.S.T.M. A table of data is included showing the agreement between aniline point as determined with the circulating test tube and by the A.S.T.M. method.

Determination of Types of Sulphur Compounds

A method for the determination of types of sulphur compounds in petroleum distillates is the basis for a report by the Bureau of Mines, Department of the Interior. Copies of Report of Investigations 3591 by John S. Ball are available through the Information Division, Washington.

This work which was done under a cooperative agreement with the University of Wyoming describes methods for analyzing petroleum distillates for hydrogen sulfide, mercaptans, free sulfur, disulfides, aliphatic sulfides, and aromatic sulfides and thiophenes.

Sulphur has long been recognized to be detrimental in many types of petroleum products, particularly gasoline, and most specifications include tests designed to protect consumers by limiting the amount of total sulphur content and excluding sulphur compounds having obnoxious odors or corrosive properties. To meet these specifications, refiners often must install costly treating processes.

Besides the objections which directly affect consumers, refiners must consider other detrimental qualities of sulphur compounds. Some sulphur compounds reduce the lead response of gasolines and thereby require the addition of more tetraethyl lead to produce the desired octane rating. The gum-forming tendency of gasoline is increased by the presence of sulphur compounds. These factors also add to the cost of processing and are reflected either in the price of the finished product, the net return to the refiner, or in the market value of the crude oils which yield high-sulphur distillates.

The same objectionable properties are not found in all sulphur compounds. Obnoxious odors, for example, are usually due to mercaptans, and low lead response is attributed to mercaptans, disulfides, and polysulfides. Thiophenes show few, if any, harmful characteristics.

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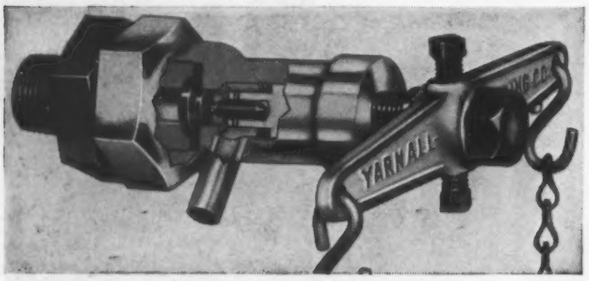
For pressures up to 600 pounds, body and stem are tobin bronze; for 600 to 1500 pounds, these parts are stainless steel. Shanks are stainless steel. Needle valve and seat are stainless steel, heat-treated; these parts reversible and renewable. To avoid interference of operating chains, the operating lever on upper try-cock is offset outward, lever on center try-cock is straight and lever on lower try-cock is offset inward. Y.H.D. Try-cocks are also made in weighted lever style with single operating chains.



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crosshead frame and directly attached to extension of displacement plunger. In this way, all lost motion due to play in either the speed reducer drive shaft or connecting rod assembly is eliminated. Indicator shows actual plunger displacement at all times while the pump is in motion.

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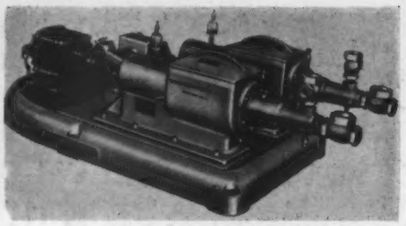

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Specifically designed for dead-end service, the remote valve control unit will hold reduced pressures, dependably, to values within very narrow limits. Although most commonly used as its name suggests, it is equally useful in other applications, such as the setting of the control points of distant instruments or the adjustment of positioning or pressure-producing pistons, located in inaccessible points. It is practical for operation over distances as great as 1000 feet.

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The economic reasons for using Jessop SILVER-PLY Stainless-Clad Steel are still valid today, but equally important is the fact that SILVER-PLY permits great savings in strategic stainless alloys. A 20% clad sheet or plate, for example, uses only 1/5 as much stainless steel as a sheet or plate of solid stainless steel of the same thickness. In other words, a given amount of stainless or of nickel and chromium can be made to perform five times as much service without sacrifice of inherent corrosion resistance, when used in the form of Jessop SILVER-PLY Stainless-Clad Steel.

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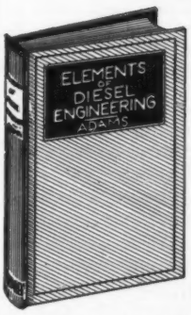

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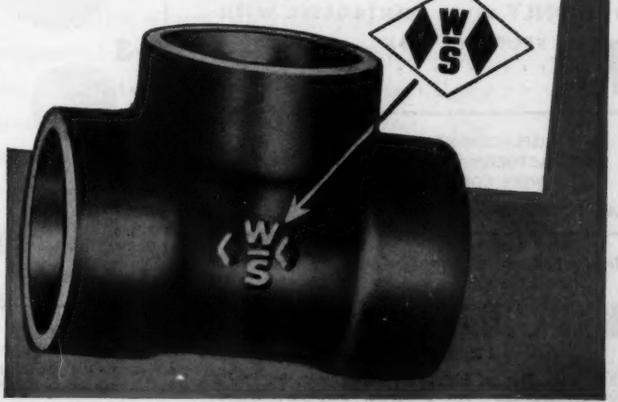

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may be unbolted and removed to work bench for new glass, or extra complete diaphragms may be carried in stock, ready for immediate installation.

A separate adapter flange is provided for mounting over foam opening in oil-tank shell. Flange surface adjoining tank shell is concave to fit curvature of tank. The outer flange face is flat, to make up to the outlet flange of the mixing chamber. The adapter flange may be fitted to oil tank during fabrication, and blanked off pending later chamber installation, if desired. The adapter flange is furnished with studs for bolting in place. A foam deflector plate is in two sections, each with two supporting struts. It may be installed from outside of oil tank, through foam opening, and bolted in place.

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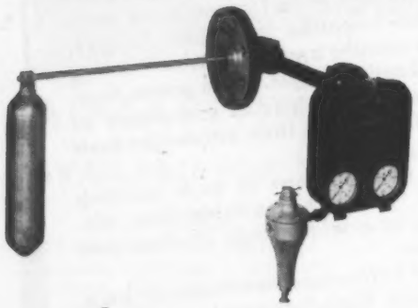

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The chamber is of expansion type design, with increasing cross-sectional area to insure intimate mixing of chemical solutions, efficient formation of foam, and low velocity delivery. "A" and "B" solution inlets at bottom of chamber impinge within a baffle, assuring a thorough mixing. A small hole in bottom plate allows air to circulate within chamber, retarding corrosion; provides drainage; acts as tell-tale upon foam discharge. Top and bottom plates may be removed periodically for painting interior. There is ample clearance between body of chamber and tank shell for outside painting.

Boring Bar

GISHOLT MACHINE COMPANY

Gisholt Machine Company, 1273 East Washington Avenue, Madison, Wisconsin, has announced a new double-end boring bar for use with saddle-type turret lathes.

Gisholt Double End Boring Bar

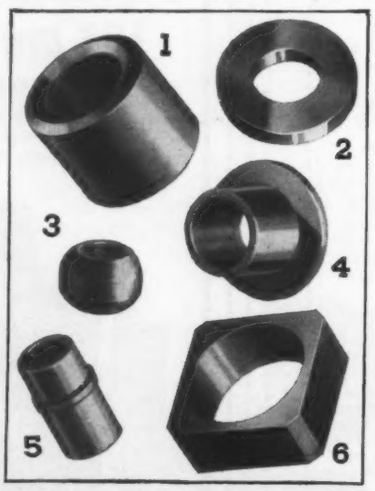
The double-end boring bar fits into the standard flanged tool holder on the turret, then through the turret, and is held on the opposite side by a short holder, having four screws to firmly grip the bar. This makes an extremely rigid bar with large single point cutters, for use with the cross feeding turret.

Porous-Iron Bearings

KEYSTONE CARBON COMPANY

Keystone Carbon Company, 1935 State Street, St. Marys, Pennsylvania, announces addition of porous-iron bearings to its line of self-lubricating bronze bearings. The new porous-iron bearings are stronger than porous-bronze bearings, and they are interchangeable with porous-bronze bearings in most applications. They were introduced to conserve copper.

Selflube porous-iron bearings are made from powdered iron, which is moulded to size in the shape desired, then baked, and finally saturated with oil. They have an average porosity of 25 to 35 percent, enabling them to store a large amount of oil which forms a protective, continuous oil film on the bearing surface. In many instances, this oil reserve lasts the life of the application, eliminating use of oil vents or grease cups. Additional lubrication is recommended for heavy duty or continuous operating units.



1 Sleeve or plain cylindrical bearing, 2 washer or thrust bearing, 3 spherical or self-aligning bearing, 4 flanged bearing. Examples of special shapes are shown at 5 and 6.

The new bearings have a low friction coefficient which, together with their self-lubricating qualities, prevents excessive temperature, speed reduction, noise and scoring of shaft. They are moulded to close dimensional tolerances so that no redesigning or special engineering is required.

Selflube porous-iron bearings are supplied in both standard and special shapes.

General Purpose Starters

GENERAL ELECTRIC COMPANY

General Electric Company, Schenectady, New York, has introduced a new line of 2300-volt 60-cycle general purpose starters especially designed for protection against short circuits and overloads.

Composed of an oil-immersed contactor with self-cleaning copper tips, wide metal bearings, and copper-braided shunts for long life, and the new EJ-2 current-limiting fuses for short circuit protection, the control and bus structure is completely metal-enclosed for compactness, easy installation, and safety.

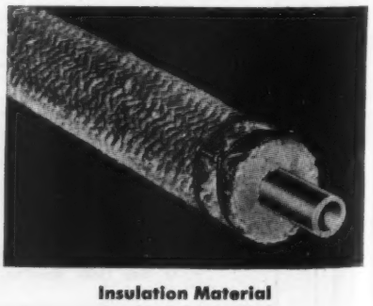
There are four standard types of starters in this new line—providing for full-voltage starting, reduced-voltage starting, and reversing of squirrel-cage motors and synchronous motors. Starters for special applications are also available.

Insulation Product

UNION ASBESTOS & RUBBER COMPANY

Problems encountered in insulating small heating lines have resulted in development of a new product known as "Insutube" by Union Asbestos & Rubber Company, 1817 S. 54th Avenue, Cicero, Illinois. Light weight, small size, and ability to adhere under severe shock and vibration are listed as features which promise to have wide appeal for many industrial installations where small pipe or tubing is used to carry hot gases or liquids.

The material is made in the form of a seamless braided tube of long-fibre asbestos with a wall thickness of ½-inch and is offered in a choice of sizes to fit pipes 1-inch I.D. and smaller. It is supplied either plain or with a water and grease-repellant coating. In applying, the insulation is slipped on before assembly and is clamped at either end after being stretched tightly lengthwise



Insulation Material

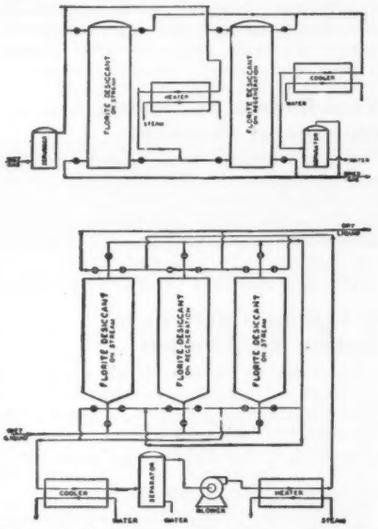
on the pipe. Simple wire clamps are available or any ordinary hose clamp can be used.

The insulation is ordinarily packaged in reels of 100 feet length, but can be furnished in any desired length. The weight averages about .30 pound per running foot in the ½-inch I.D. size. The standard grade is recommended for temperatures up to 500° F., and special material can be supplied for higher temperatures.

Drying Agent

FLORIDIN COMPANY

Floridin Company, 179 Liberty Street, Warren, Pennsylvania, has announced "Florite Desiccant," a new granular drying agent for gases and liquids. It has found use in a variety of industrial processes requiring bone-dry gases and liquids, and in many installations where high drying efficiency is not ordinarily demanded. Among the products now being dehydrated are natural gas, propane, gasoline, air, nitrogen and carbon dioxide. It may also be used in breathers for storage tanks and electrical transformers, to dehumidify air in air conditioning systems and to dehydrate refrigerants.



Dehydration plant for gases, top, and dehydration for liquids.

The outstanding characteristic claimed for Florite Desiccant is its ability to maintain a high drying efficiency under conditions that have rendered competitive materials useless. It adsorbs water instantly and will not swell, disintegrate, or appear wet at the end of an adsorption sycle. It is hard, stable, non-corrosive, and non-poisonous. It selectively adsorbs 4 to 20 percent of its weight in water, depending on the particular application, and is regenerated by heating to 300-350° F., it was said.

Midget Size Pump

EASTERN ENGINEERING COMPANY

Eastern Engineering Company, 45 Fox Street, New Haven, Connecticut, has introduced another model in its line of midget size pumps. Model D is air powered and explosion proof. The pump can be used in all industrial pilot plant, laboratory and experimental applications where an explosion-proof motor is necessary and where compressed air is available.

Magnesium Plant to Use Natural Gas

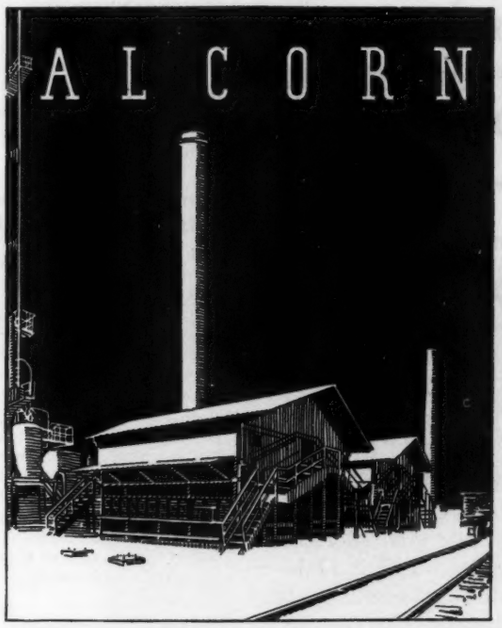
Production of metallic magnesium by a new process, part of which is the use of natural gas, will be undertaken by Mathieson Alkali Works, which has signed a contract with Defense Plant Corporation. The latter will own the plant and operation will be by Mathieson Alkali Works.

This company perfected the process in conjunction with Consolidated Mining and Smelting Company.

This process differs from other processes for making magnesium electrolytically, in that it does not consume chlorine but produces it in such concentration that it can be collected and liquefied.

The raw material is dolomite, a rock resembling limestone and consisting of calcium-magnesium carbonate, which will be shipped from nearby quarries. This material is calcined, using locally produced natural gas for the purpose, and the resulting oxides of calcium and magnesium are treated with calcium chloride, a product of the process by which soda ash is made at one of the nearby Mathieson plants. The mass is then treated with carbon dioxide, obtained from the calcination of the dolomite, which converts the calcium into the insoluble carbonate, leaving magnesium chloride.

The magnesium chloride, after being concentrated, is electrolyzed in a new type of cell. The products are metallic magnesium and chlorine, both of which are essential war materials.



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INSTALLATIONS may be on large scale, built for permanence. Or may be small scale, built to utilize a new, untried, possibly soon to be exhausted field. The problems of construction vary in the two cases—and in many others in between. One factor remains constant. The cheapest way to get the best result in processing oil for any purpose is to select the best heat application procurable.

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☆ BUSINESS NOTES ☆

Stevenson Promoted by American Meter Company

George Stevenson has been appointed assistant manager of the Pacific Coast factory and sales service of American Meter Company with headquarters in Los Angeles. He has been with the organization for 14 years and for the past six years has been sales engineer in the Los Angeles office.

John J. Linker Joins Crane Packing Company

John J. Linker has been placed in charge of production and development of metallic and fabric packings and mechanical pump seals for Crane Packing Company, Chicago.

Previously he was with the Flintkote Corporation in similar activity and he has had experience in mechanical engineering with Stone and Webster Engineering Corporation and several marine companies.

Landis Machine Company Adds Another Building

The Landis Machine Company has completed an addition to its plant in Waynesboro, Pennsylvania, to facilitate present operations and materially increase its manufacturing capacity.

The addition includes a large structure 60 by 350 feet which will house a new erecting floor and shipping department. A wing, 50 by 80 feet, extending from the main structure at the shipping department will house a box and crate manufacturing department as well as a lumber storage. A second building 30 by 60 feet, one story, and made entirely of brick and reinforced concrete, provides a convenient means for the storage of chips and cuttings.

Sawyer Company Names Eastern Sales Manager

Sawyer Electrical Manufacturing Company, Los Angeles, announces appointment of George M. Snodgrass as manager of its Eastern sales division, headquarters for which will be at 2110 Terminal Tower, Cleveland, Ohio.

Before his appointment, Snodgrass was vice president and sales manager of Imperial Electric Company, Akron, Ohio. Prior to that, he had been sales manager of the electrical division of Fairbanks, Morse & Company.

A wholly-owned subsidiary of A. O. Smith Corporation, Milwaukee, the Sawyer company manufactures a line of special electric motors for machine tools as well as rotors and stators for built-in applications.

C. F. Rassweiler Promoted By Johns-Manville

Dr. C. F. Rassweiler, who joined Johns-Manville Corporation last June as director of research, was appointed a vice president of the corporation. He will continue in charge of the company's research and development activities which are largely devoted to converting the full production capacity to war uses. Intensive studies of new products and new business possibilities for J-M which may be introduced to create additional employment and sales after the war is over, are also being conducted.

Johns-Manville's research laboratories are located in Manville, N. J., and are managed by E. R. Williams, who will continue in that capacity.

Albert A. Haniford Joins Manning, Maxwell & Moore

Albert A. Haniford has joined the sales staff of Manning, Maxwell & Moore, Inc., Bridgeport, Connecticut, to extend the program of sales training to the sales staff.

As assistant to the director of dealer relations of Johns-Manville Corporation he was instrumental in development of the National Housing Guild. He was previously sales manager of Pyroneel Company, New York.

Walter Williams has been assigned to the St. Louis territory of the company to take the place left by Harold Moore, who has gone into military service. Williams formerly was in the Chicago office.

Voss Retires as Timken Director of Purchases

Peter Voss, director of purchases, has retired from Timken Roller Bearing Company, with which he was connected for 24 years. He first served as clerk in the purchasing department, became purchasing agent in 1923 and held the latter position from 1934 until his retirement.

E. L. Dennis Returns to Coppus Corporation

In order to devote all his time to the problem of efficient combustion in industrial plants Edwin L. Dennis, chief combustion engineer of the Coppus Engineering Corporation, has given up his duties as instructor at Louisiana State University, Baton Rouge.

His services particularly in connection with the requirements of gas-burning boilers, stills, heaters and kilns will henceforth be available to customers of the corporation on a full-time basis.

Personnel Changes in Elliott Company

Several changes in personnel of the Elliott Company, Jeannette, Pennsylvania, have been made and some additions to the sales and engineering staffs have been announced.

J. E. Niederhauser has been appointed personnel director and will function in the employment and training of new men, and in safety and first-aid work. Niederhauser comes from Greenfield Tap & Die Corporation, and was also with the Harris-Seybold-Potter Company, of Cleveland, for many years.

J. F. Brisse has been appointed production manager. He will be directly responsible for production planning, material control methods and procedures at each of the three Elliott plants. Brisse has been with Hudson Motor Car Company for 23 years in production and planning work.

H. L. Dinsmore has been appointed chief industrial engineer. He will supervise, in collaboration with executives in charge at each plant, the acquisition, arrangement, and location of manufacturing facilities, the setting of standards in production planning, deter-

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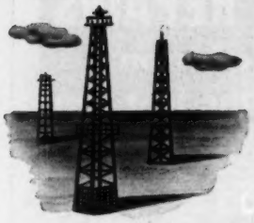

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ENGINEERS • MACHINISTS

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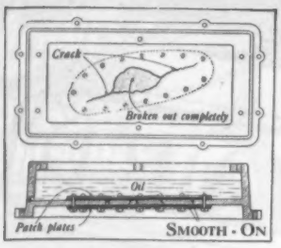
. . . a lesson from the last war



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mine manufacturing methods. Dinsmore comes from the firm of consulting engineers, Coverdale and Colpitts of New York. He was with Miller, Franklin, and Basset & Co., of New York, industrial engineers, for 15 years and has also been with several industrial concerns in the same capacity.

C. C. Hutchins, who has been electrical engineer for 14 years, has been appointed executive engineer of the Ridgway Works, in charge of product engineering with the exception of naval engineering. I. S. Nippes continues as manager of the naval department.

Eugene B. Worth has joined the turbine sales department, Jeannette. He comes from Hercules Powder Company, where he was doing engineering and supervisory work. He has had a number of years of experience in power plant engineering and in field selling.

Lieutenant Floyd L. Humphrey, former field engineer in the Atlanta office and more recently in the turbine department in Jeannette, has reported for active duty with a unit of the Coast Artillery.

John H. Barnard, 1941 graduate of Rensselaer Polytechnic Institute, a mechanical engineer, has joined the turbine department. He came to Elliott Company, after graduation, as an apprentice.

Charles H. Carman Jr., another 1941 mechanical engineering graduate of Rensselaer, has been assigned as field engineer to the Washington office.

Administrative Changes at Industrial Engineering

Through the election of officials, changes have been made in the administrative organization of Industrial Engineering Company. Plants are in Houston, and Wilmington, California.

H. C. Price, H. C. Price & Company, Bartlesville, is president; W. W. Colley, Houston, is vice president and general manager with K. H. Dyer, Wilmington, Pacific Coast manager. Other officials are S. D. Bechtel, San Francisco, chairmen of the board; W. E. Waste, Los Angeles, secretary. These with Henry J. Kaiser and G. C. Sherwood, Oakland, comprise the board of directors.

Offices are in Houston, Wilmington, Bartlesville and San Francisco.

Pomona Pump Buys Westco Pump Division

Pomona Pump Company, Pomona, California, has purchased the Westco Pump Division of Micro-Westco, Inc., Bettendorf, Iowa.

The acquired business will be operated as Westco Division, 2621 Locust Street, St. Louis, Missouri, and manufacture continued from the St. Louis plant of the Pomona Pump Company. Management and key personnel of Westco will be transferred to St. Louis to continue the manufacture and distribution of Westco pumps through the same national organization which has been built up over the past 16 years.

Addition of the Westco turbine pump for industrial and marine application, also boiler-feed and condensation units, side-suction centrifugals, complete water systems, line and cellar drainers, rounds out the line of Pomona deep well, low lift, industrial, marine and municipal pumps. During the last few years Pomona has added the Little Chief turbine pump and also Pomona deep- and shallow-well jets.

Walter Geist Heads New Allis-Chalmers Department

Walter Geist, vice president of Allis-Chalmers Manufacturing Company, Milwaukee, is to head a new department, established to coordinate the company's sales policies.

"The matters of sales and sales organization have become very complex because of the company's all-out war effort which puts practically its entire productive capacity at the disposal of the Army, Navy, and the vast number of manufacturers producing material vital to our war efforts," W. C. Buchanan, company president, said, "and the resulting problems make necessary this new centralized sales administrative department."

The duties of this department will be not only to formulate and put into effect sales policies, but also to correlate and unify the selling activities for all the company's 1600 products, with the exception of those of the tractor department.

Changes in U. S. Steel Public Relations Staff

Appointments of W. Everett McLaine as director of public relations and Edward C. Myers as issistant director of public relations for United States Steel subsidiaries in the Pittsburgh district have been announced. At the same time it was announced that Walter E. Camp will become assistant to J. Carlisle MacDonald, assistant to the chairman of the board of directors of United States Steel Corporation in New York, who, for the chairman of the board of directors, exercises general direction of pub-

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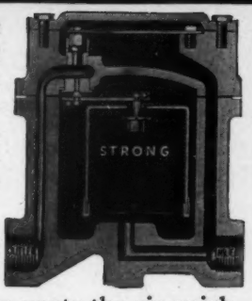

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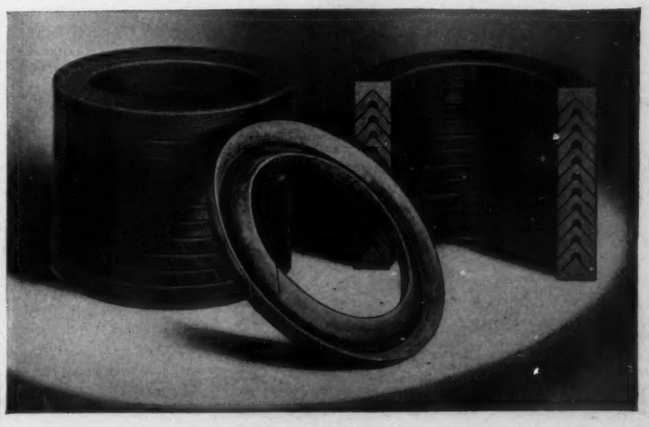

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lic relations activities of the corporation and its subsidiary companies.

The public relations offices for the Pittsburgh district will be located at 436 Seventh Avenue. Working directly under the president of United States Steel Corporation of Delaware and the presidents of the subsidiary companies in the Pittsburgh district, McLaine will be responsible for all public relations functions of these subsidiaries in the Pittsburgh district.

McLaine has been in charge of the public relations activities in the Washington office of United States Steel subsidiaries. Mr. Myers has been on the public relations staff of United States Steel Corporation of Delaware in Pittsburgh. Camp has been director of public relations, Pittsburgh district, Carnegie-Illinois Steel Corporation.

President of Frick Company Dies

Ezra Frick, president of Frick Company, Waynesboro, Pennsylvania, died there February 2 at the age of 86. His first work, as an apprentice, started in 1875 and he had more than 65 years of contact with the refrigeration industry which was developed during his active period in business.

His duties with the company were as apprentice, foreman, general clerk, purchasing agent, general manager and treasurer prior to his election as president in 1924.

As a pioneer in the refrigerating and ice-making industry, Frick was one of the founders of the Ice Machinery Builders' Association, and became its secretary in 1908. He was president of the Refrigerating Machinery Association for the year 1919-20, and was elected an honorary member of that association in 1936. He was one of the charter members of the American Society of Refrigerating Engineers, and was made its president for the year 1918. He was also a member of the American Institute of Refrigeration. At the time of his death, he was president of the Citizens National Bank and Trust Company of Waynesboro. He was a director of the Knickerbocker Stamping Company, Parkersburg, West Virginia, and a director of the Landis Tool Company, Waynesboro.

Oakite Expands Facilities; Adds Two New Divisions

To better meet increased needs for its services and products by the producing, refining, transportation and distributing divisions of the petroleum industry in New England and the Southwest, Oakite Proudcts, Inc., manufacturers of industrial cleaning materials since 1909, has announced the addition of two newly created divisions to its nationwide field service staff.

The New England division, with headquarters in Hartford, Connecticut, is headed by T. R. Smith, who will supervise the activities of the 11 men comprising this division. The second division is the St. Louis and Southwestern Division, which will make its headquarters in St. Louis. S. C. Shank is Division Manager.

Smith has served for the past 16 years as Oakite service representative in a major eastern industrial area while Shank has covered a Midwestern territory since 1930.

Gautier on Board of Maintenance Engineering

C. W. Gautier has been elected secretary-treasurer of Maintenance Engineering Corporation, Houston, and placed on the board of directors of the company, effective February 1. His election follows the death January 14 of L. J. Burda, whose position he had filled through the latter's extended illness. Gautier joined the Maintenance Engineering Corporation staff 14 years ago.

C. W. Gautier

O. E. Dustman, Southern California manager of the Ralph N. Brodie Company, with offices in Los Angeles, died February 3, in Los Angeles. He headed the Brodie Los Angeles office for more than nine years.

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